REPORT DOCUMENTATION PAGE

Form Approved OMB NO. 0704-0188

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE:	3. REPORT TYPE AND DATES COVERED Final Report 1-Aug-2000 - 31-Jan-2006

4. TITLE AND SUBTITLE
A Comprehensive Approach to Fusion for Microsensor Networks: Distributed and Hierarchical Inference, Communication, and Adaption

5. FUNDING NUMBERS
DAAD190010466

6. AUTHORS
John W. Fisher, III, Mujdat Cetin, Tommi Jaakkola, John Tsitsiklis, Sergio Verdu, Sanjeev Kulkarni, P.R. Kumar, Alan S. Willsky, Sanjoy K. Mitter

8. PERFORMING ORGANIZATION REPORT NUMBER

7. PERFORMING ORGANIZATION NAMES AND ADDRESSES
Massachusetts Institute of Technology
Office of Sponsored Programs
Bldg. E19-750
Cambridge, MA 02139 -4307

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709-2211

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
41051-MA-MUR.24

11. SUPPLEMENTARY NOTES
The views, opinions and/or findings contained in this report are those of the author(s) and should not contrued as an official Department of the Army position, policy or decision, unless so designated by other documentation.

12. DISTRIBUTION AVAILIBILITY STATEMENT
Approved for Public Release; Distribution Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)
The abstract is below since many authors do not follow the 200 word limit

14. SUBJECT TERMS
Fusion, Sensor Networks, Wireless Networks, Adaptation and Self-Organization, Network Communication and Information Theory

15. NUMBER OF PAGES
Unknown due to possible attachments

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION ON THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev .2-89)
Prescribed by ANSI Std.
239-18 298-102

Report Title

Data Fusion in Large Arrays of Microsensors (SensorWeb): A Comprehensive Approach to Fusion for Microsensor Networks—Distributed and Hierarchical Inference, Communication, and Adaptation

ABSTRACT

This final report summarizes the research and activities under the ODDR&E MURI on Data Fusion in Large Arrays of Microsensors. The report reviews the intellectual themes and research concentration areas of this program, provides a listing of all personnel involved in the program and the infrastructure and website created; summarizes highlights of the impact our work has already had; lists many of the awards and recognition we have received; describes interactions with and transitions to DoD activities as well as the infrastructure we have put in place (including the program website which will continue into the future); and briefly summarizes the major research accomplishments we have had. The report closes with a complete listing of the very substantial list of publications that have resulted from research supported by this project.

List of papers submitted or published that acknowledge ARO support during this reporting period. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

1. A. Agarwal, P. R. Kumar. Capacity bounds for ad-hoc and hybrid wireless networks. ACM SIGCOMM Computer Communication Review: Special Issue on Science of Networking Design, vol. 34, no. 3, July 2004. pp. 71-81.
2. A. Agarwal, P. R. Kumar. Improved Capacity Bounds for Wireless Networks. Wireless Communications and Mobile Computing, vol. 4, May 2004. pp. 251-261.
3. G. Baliga, P. R. Kumar. Middleware Architecture for Federated Control Systems. IEEE Distributed Systems Online, June 2003.
4. P. L. Bartlett, S. Ben David, S. R. Kulkarni. Learning Changing Concepts by Exploiting the Structure of Change. Machine Learning, November 2000. pp. 153-174.
5. L. Bazzi, S.K. Mitter. Encoding Complexity Versus Minumum Distance. IEEE Trans. on Info. Theory, vol. 51 no. 6, June 2005. pp. 2103-2112.
6. V. Borkar, P. R. Kumar. Dynamic Cesaro-Wardrop Equilibration in Networks. IEEE Transactions on Automatic Control, vol. 48, no. 3, March 2003. pp. 382-396 .
7. V.S. Borkar, V.R. Konda, S.K. Mitter. On De Finetti Coherence and Kolmogorov Probability. Stat. Prob. Lett, 66, 2004. pp. 417-421.
8. V.S. Borkar, S.K. Mitter, S.R. Venkatesh. Variations on a Theme by Neyman and Pearson. Sankhya, vol. 66, part II, May 2004. pp. 292-305.
9. H. Cai, S.R. Kulkarni, S. Verdu. Universal Estimation of Entropy Via Block Sorting. IEEE Transactions on Information Theory, vol. 50, no. 7, July 2004. pp. 1551-1561.
10. G. Caire, S. Guemghar, A. Roumy, S. Verdu. Maximizing the Spectral Efficiency of coded CDMA under successive decoding. IEEE Transactions on Information Theory, vol. 50, no. 1, January 2004. pp. 152-164.
11. G. Caire, D. Tuninetti, S. Verdu. Suboptimality of TDMA in the low power regime. IEEE Transactions on Information Theory, vol. 50, no. 4, April 2004. pp. 608-620.
12. G. Caire, S. Shamai and S. Verdu. Noiseless Data Compression with Low-Density Parity-Check Codes. DIMACS Series in Discrete Mathematics and Theoretical Computer Science, 2004. pp. 263-284.
13. G. Caire, D. Tuninetti, and S. Verdu. Variable-rate Coding for Slowly-fading Gaussian Multiple-access Channels. IEEE Transactions on Information Theory, October 2004. pp. 2271-2292.
14. G. Caire, S. Shamai, A. Shokrollahi and S. Verd\'{u}. Fountain Codes for Lossless Data Compression. {\em Algebraic Coding Theory and Information Theory}, A. Ashikhmin, A. Barg, I. Duursma, DIMACS Series in Discrete Mathematics and Theoretical Computer Sciences, vol.\ 68, pp.\ 1-20, American Mathematical Society Press, 2005.
15. M. Chu, H. Haussecker, F. Zhao. Scalable Information-Driven Sensor Querying and Routing for ad hoc Heterogeneous Sensor Networks. International Journal of High Performance Computing Applications.
16. A. Corduneanu, T. Jaakkola. Data dependent regularization. (to appear in:) "Semi-supervised learning", O. Chapelle, A. Zien, B. Sch˚lkopf (eds.), 2005.
17. M. Dmitry, M. Cetin, and A.S. Willsky. Sparse Signal Reconstruction Perspective for Source Localization with Sensor Arrays. Transactions on Signal Processing, 2005.
18. M. Effros, K. Visweswariah, S. Kulkarni, S. Verdu. Universal Lossless Source Coding With the Burrows Wheeler Transform. IEEE Transactions on Information Theory, May 2002. pp. 1061-1081.
19. John W. Fisher III, Martin Wainwright, Erik Sudderth, Alan S. Willsky. Statistical and Information-Theoretic Methods For Self-Organization And Fusion Of Multimodal, Networked Sensors. In Review, September 2001.
20. A. Fu, E. Modiano, J. N. Tsitsiklis. Optimal Transmission Scheduling over a Fading Channel with Energy and Deadline Constraints. IEEE Transactions on Wireless Communications, February 2006.
21. A.P. George, W.B. Powell, S.R. Kulkarni. The Statistics of Hierarchical Aggregation for Multiattribute Resource Management. INFORMS Journal on Computing.
22. A. Giridhar, P. R. Kumar. Maximizing the Functional Lifetime of Sensor Networks. Proceedings of The Fourth International Conference on Information Processing in Sensor Networks, IPSN 2005, April 2005.
23. A. Giridhar, P. R. Kumar. Computing and Communicating functions over Sensor Networks. IEEE Journal on Selected Areas in Communication, vol. 23, no. 4, April 2005. pp. 755-764.
24. D. Guo, S. Verdu, L. K. Rasmussen. Asymptotic normality of linear multiuser receiver outputs. (to appear in:) IEEE Transactions on Information Theory.
25. D. Guo, S. Shamai, and S. Verdu. Mutual Information and Minimum Mean-Square Error in Gaussian Channels. IEEE Transactions on Information Theory, April 2005. pp. 1261-1283.
26. D. Guo, S. Verdu. Randomly Spread CDMA: Asymptotics via Statistical Physics. IEEE Transactions on Information Theory, June 2005. pp. 1983-2010.
27. N. Gupta, P. R. Kumar. A performance analysis of the IEEE 802.11 Wireless LAN Medium Access Control. (to appear in:) Communications in Information and Systems, Revised June, 2004.
28. P. Gupta, P. R. Kumar. Towards an Information Theory of Large Networks: An Achievable Rate Region. IEEE Trans. on Information Theory, vol 49, no. 8, August 2003. pp. 1877-1894.
29. M. Gursoy, H. V. Poor and S. Verd\'{u}. The Noncoherent Rician Fading Channel -- Part II: Spectral Efficiency in the Low-Power

Regime. IEEE Trans. Wireless Communications, vol. 4, no. 5, pp. 2207- 2221, Sep 2005.
30. M. Gursoy, H. V. Poor and S. Verd\'{u}. On-Off Frequency-Shift-Keying for Wideband Fading Channels. (to appear in:) EURASIP Journal on Wireless Communications and Networking, no. 1, 2006.
31. A. Ihler, J. W. Fisher III, A. S. Willsky. Loopy Belief Propagation: Convergence and Effects of Message Errors. Journal of Machine Learning Research, May 2005.
32. A. Ihler, J. W. Fisher III, R. L. Moses, A. S. Willsky. Nonparametric Belief Propagation for Sensor Network Self-Calibration. IEEE Journal of Selected Areas in Communications, April 2005.
33. A. Ihler, J. W. Fisher III, A. S. Willsky. Nonparametric Hypothesis Tests for Statistical Dependency. Transactions on Signal Processing, August 2004.
34. T. Jaakkola. Tutorial on variational approximation methods. Advanced mean field methods: theory and practice, MIT Press, 14, September 2000.
35. J.K. Johnson, A.S. Willsky. A Recursive Model-Reduction Method for Approximate Inference in Gaussian Markov Random Fields. IEEE Trans. Image Processing, June 2005.
36. A.Jovicic, P. Viswanath, S.R. Kulkarni. Upper Bounds to Transport Capacity of Wireless Networks. IEEE Transactions on Information Theory.
37. V. Kawadia, P. R. Kumar. A Cautionary Perspective on Cross Layer Design. IEEE Wireless Communication Magazine, vol. 12, no. 1, February 2005. pp. 3-11.
38. V. Kawadia, P. R. Kumar. Principles and Protocols for Power Control in Wireless Ad Hoc Networks. IEEE Journal on Selected Areas in Communications, vol. 23, no. 1, January 2005. pp. 76-88.
39. S. R. Kulkarni, G. Lugosi. Finite Time Lower Bounds for the Two-Armed Bandit Problem. IEEE Transactions on Automatic Control, April 2000. pp. 711-714.
40. S.R. Kulkarni, S.E. Posner, S. Sandilya. Data-dependent kn-NN and Kernel Estimators Consistent for Arbitrary Processes. IEEE Transactions on Information Theory, October 2002.
41. S.R. Kulkarni, P. Viswanath. A Deterministic Approach to Throughput Scaling in Wireless Networks. IEEE Transactions on Information Theory, vol. 50, no. 6, June 2004. pp. 1041-1049.
42. L. Li, A. Tulino, S. Verdu. Asymptotic Eigenvalue Moments for Linear Multiuser Detection. Communications in Information and Systems, September 2001. pp. 273-304.
43. L. Li, A. M. Tulino, S. Verdu. Design of Reduced-rank MMSE Multiuser Detectors using Random Matrix Methods. IEEE Transactions on Information Theory, vol. 50, no. 6, June 2004. pp. 986-1008.
44. A. Lozano, A. M. Tulino and S. Verd\'{u}. High-SNR Power Offset in Multi-Antenna Communication. IEEE Trans. Information Theory, vol. 51, no. 12, pp. 4134- 4151, Dec. 2005.
45. A. Lozano, A. Tulino and S. Verd\'{u}. Multiantenna capacity: Myths and Realities. Chapter 8 in {\em Space-Time Wireless Systems: from Array Processing to MIMO Communications}, H. B\"{o}lcskei, D. Gesbert, C. Papadias, and A.J. van der Veen, Eds., Cambridge University Press, 2006.
46. A. Lozano, A. M. Tulino and S. Verd\'{u}. Capacity-Achieving Input Covariance for Single-user Multi-Antenna Channels. (to appear in:) IEEE Trans. Wireless Communications, Feb. 2006.
47. S. Mannor, R. Meir, T. Zhang. Greedy Algorithms for Classification -- Consistency, Convergence Rates, and Adaptivity. Journal of Machine Learning Research, vol. 4, October 2003. pp. 713-741.
48. S. Mannor, J. N. Tsitsiklis. The Sample Complexity of Exploration in the Multi-Armed Bandit Problem. Journal of Machine Learning Research, vol. 5, June 2004. pp. 623-648.
49. S.K. Mitter. Duality Between Estimation and Control. Festschrift for A. Bensoussan, December 2000.
50. S.K. Mitter. Control with Limited Information. Eur. Jrn. Control, vol. 7, 2001. pp. 122-131.
51. S.K. Mitter, N. J. Newton. A Variational Approach to Nonlinear Estimation. SIAM Journal on Control, vol. 42, no. 5, 2004. pp. 1813-1833.
52. S.K. Mitter, N.J. Newton. Information and Entropy Flow in the Kalman-Bucy Filter. J. of Stat. Phys., vol. 118, 2005. pp. 145-176.
53. R. Mueller, S. Verdu. Design and Analysis of Low-Complexity Interference Mitigation on Vector Channels. IEEE Journal on Selected Areas on Communications, August 2001. pp. 1429-1441.
54. D.P. Palomar and S. Verd\'{u}. Gradient of Mutual Information in Linear Vector Gaussian Channels. IEEE Trans. on Information Theory, Vol. 52, no. 1, pp. 141-154, Jan. 2006.
55. K. Plarre, P. R. Kumar. Extended Message Passing Algorithm for Inference in Loopy Gaussian Graphical Models. Ad Hoc Networks, vol. 2, 2004. pp. 153-169.
56. V. V. Prelov, S. Verdu. Second-order Asymptotics of Mutual Information. IEEE Transactions on Information Theory, August 2004. pp. 1567-1580.
57. A. Reznik, S.R. Kulkarni, S. Verdu. Capacity and Optimal Resource Allocation in the Degraded Gaussian Relay Channel with Multiple Relays. IEEE Transactions on Information Theory.
58. A. Reznik, S.R. Kulkarni, S. Verdu. A Small World Approach to Heterogeneous Networks. Communications in Information and

Systems, September 2004. pp. 325-348.
59. A. Reznik, S.R. Kulkarni, S. Verdu. Degraded Gaussian multi-relay channel: capacity and optimal power allocation. IEEE Transactions on Information Theory, December 2004. pp. 3037-3046.
60. S. Rickard, R. Balan, H. V. Poor and Verd\'{u}. Canonical Time-Frequency, time-scale and frequency-scale representations of time-varying channels. Communications in Information and Systems, vol. 5, no. 1, pp. 197-226, 2005.
61. S. Sandilya, S.R. Kulkarni. Principal Curves with Bounded Turn. IEEE Transactions on Information Theory, October 2002.
62. S. (Shitz) Shamai, S. Verdu. Decoding only the Strongest CDMA Users. Codes, Graphs, and Systems. pp. 217-228.
63. S. (Shitz) Shamai, S. Verdu. Decoding only the Strongest CDMA Users. Forney Festshrift, 2001.
64. S. Shamai, S. Verdu. The Impact of Frequency-flat Fading on the Spectral Efficiency of CDMA. IEEE Transactions on Information Theory, May 2001. pp. 1302-1327.
65. E. Sudderth, M. J. Wainwright, A. S. Willsky. Embedded Trees: Estimation of Gaussian Processes on Graphs with Cycles. IEEE Transactions on Signal Processing, November 2004. pp. 3136-3150.
66. R. Sundaresan and S. Verd\'{u}. Capacity of Queues via Point-Process Channels," (to appear in:) IEEE Trans. Information Theory, 2006.
67. Y.-P. Tan, D. D. Saur, S. R. Kulkarni, P. J. Ramadge. Rapid Estimation of Camera Motion from Compressed Video With Application to Video Annotation. IEEE Transactions on Circuits and Systems for Video Technology, February 2000. pp. 133-146.
68. S. Tatikonda, S.K. Mitter. Control over Noisy Channels. IEEE Trans. on Auto. Control, vol. 9 no. 7, July 2004. pp. 1196-1201.
69. S. Tatikonda, S.K. Mitter. Control under Communication Constraints. IEEE Trans. on Auto. Control, vol. 9 no. 7, July 2004. pp. 1056-1068.
70. S. Tatikonda, A. Sahai, S.K. Mitter. Stochastic Linear Control over a Communication Channel. IEEE Trans. on Auto. Control, Special Issue on Networked Control Systems, vol. 49 no. 9, September 2004. pp. 1549-1561.
71. A. Tulino, S. Verdu. Asymptotic Analysis of Improved Linear Receivers for BPSK-CDMA subject to Fading. IEEE Journal on Selected Areas on Communications, August 2001. pp. 1544-1555.
72. A. Tulino, S. Verdu. Random Matrices and Wireless Communications. Foundations and Trends in Communications and Information Theory, vol. 1, no. 1, June 2004.
73. A. Tulino, A. Lozano, S. Verdu. Impact of antenna correlation on the capacity of multiantenna channels. IEEE Trans. Info. Theory, July 2005. pp. 2491-2509.
74. A. Tulino, L. Li and S. Verdu. Spectral Efficiency of Multicarrier CDMA. IEEE Transactions on Information Theory, February 2005. pp. 479-505.
75. S. Verdu. Recent Results on the Capacity of Wideband Channels in the Low Power Regime. IEEE Personal Communications Magazine, August 2002.
76. S. Verdu. Spectral Efficiency in the Wideband Regime (Invited Paper). IEEE Trans. Information Theory, Special Issue on Shannon Theory: Perspective, Trends and Applications, June 2002. pp. 1319-1343.
77. M. Vidyasagar, S. R. Kulkarni. Some Contributions to Fixed-Distribution Learning Theory. IEEE Transactions on Automatic Control, February 2000. pp. 217-234.
78. K. Visweswariah, S. R. Kulkarni, S. Verdu. Asymptotically Optimal Variable-to-Fixed Length Codes for Markov Sources. Journal of Combinatorics, Information, and System Sciences, 2000.
79. K. Visweswariah, S. R. Kulkarni, S. Verdu. Separation of random number generation and resolvability. IEEE Transactions on Information Theory, September 2000. pp. 2237-2241.
80. K. Visweswariah, S. R. Kulkarni, S. Verdu. Universal Coding of Nonstationary Sources. IEEE Transactions on Information Theory, July 2000. pp. 1633-1637.
81. K. Visweswariah, M. Effros, S. Kulkarni, S. Verdu. Data compression based on the Burrows-Wheeler transform: Analysis and optimality. IEEE Transactions on Information Theory, 2001. pp. 1461-1472.
82. K. Visweswariah, S. Kulkarni, S. Verdu. Universal Variable-to-Fixed Length Source Codes. IEEE Transactions on Information Theory, May 2001. pp. 1461-1472.
83. M.J. Wainwright, T.S. Jaakkola, A.S. Willsky. A new class of upper bounds on the log partition function. (to appear in:) IEEE Trans. on Info. Theory, 2005.
84. M.J. Wainwright, E. P. Simoncelli, A. S. Willsky. Random cascades on wavelet trees and their use in analyzing and modeling natural images. Applied Computational and Harmonic Analysis (Special issue on wavelet applications), April 2001.
85. M.J. Wainwright, T.S. Jaakkola, A.S. Willsky. Tree consistency and bounds on the performance of the max-product algorithm and its generalizations. Statistics and Computing, vol. 14, no. 2, 2004. pp. 143-166.
86. C.-C. Wang, S.R. Kulkarni, H.V. Poor. Density Evolution for Asymmetric Memoryless Channels. IEEE Trans. on Info. Theory.
87. C.-C. Wang, S.R. Kulkarni, H.V. Poor. Arbitrary Side Observations in Bandit Problems. Annals of Applied Probability, 2003.
88. C.-C. Wang, S.R. Kulkarni, H.V. Poor. Arbitrary Side Observations in Bandit Problems. Advances in Applied Mathematics, May 2005. pp. 903-938.
89. C.-C. Wang, S.R. Kulkarni, H.V. Poor. Bandit Problems With Side Observations. IEEE Trans. on Auto. Control, May 2005. pp.

338-355.
90. Q. Wang, S. Kulkarni and S. Verdu. Divergence estimation of continuous distributions based on data-dependent partitions. IEEE Trans. on Info. Theory, September 2005.
91. Q. Wang, S. Kulkarni and S. Verd\'{u}. Divergence Estimation of Continuous Distributions based on Data-Dependent Partitions. IEEE Trans. Information Theory, vol. 51, no. 9, pp. 364-374, Sep 2005.
92. T. Weissman, E. Ordentlich, G. Seroussi, S. Verdu and M. Weinberger. Universal Discrete Denoising: Known Channel. IEEE Trans. on Info. Theory, January 2005. pp. 5-28.
93. Alan S. Willsky. Multiresolution Markov Models for Signal and Image Processing. Proceedings of the IEEE, vol. 90, no. 8, August 2002. pp. 1396-1458.
94. L.-L. Xie, P. R. Kumar. On the path-loss attenuation regime for positive cost and linear scaling of transport capacity in wireless networks. (to appear in:) IEEE Trans. on Info. Theory.
95. L.-L. Xie, P. R. Kumar. A Network Information Theory for Wireless Communication: Scaling Laws and Optimal Operation. IEEE Transactions on Information Theory, vol. 50, no. 5, May 2004. pp. 748-767.
96. L.-L. Xie, P. R. Kumar. An achievable rate for the multiple-level relay channel. IEEE Trans. on Info. Theory, vol. 51, no. 4, April 2005. pp. 1348-1358.
97. F. Xue, L-L. Xie, P. R. Kumar. Wireless Networks over Fading Channels. (to appear in:) IEEE Trans. on Info. Theory.
98. F. Xue, P. R. Kumar. On the Theta-coverage and connectivity of large random networks. (to appear in:) IEEE Trans. on Info. Theory.
99. F. Xue, P. R. Kumar. The number of neighbors needed for connectivity of wireless networks. Wireless Networks, vol. 10, no. 2, March 2004. pp. 169-181.
100. F. Xue, L-L. Xie, P. R. Kumar. The Transport Capacity of Wireless Networks over Fading Channels. IEEE Trans. on Info. Theory, vol. 51, no. 3, March 2005. pp. 834-847.
101. Zaidel, S. Shamai (Shitz), S. Verdu. Multi-cell uplink spectral efficiency of Coded DS-CDMA with Random Signatures. IEEE Journal on Selected Areas on Communications, August 2001. pp. 1556-1569.

Number of Papers published in peer-reviewed journals: 101.00

(b) Papers published in non-peer-reviewed journals or in conference proceedings (N/A for none)

1. G. Alfano, A. Lozano, A. Tulino and S. Verdu. Mutual Information and Eigenvalue Distribution of MIMO Ricean Channels. 2004 International Symposium on Information Theory and its Applications, October 2004.
2. G. Alfano, A. Lozano, A. Tulino and S. Verd\'{u}. Random Matrix Transforms and Applications Via Nonasymptotic Eigenanalysis. 2006 International Zurich Seminar, (invited paper), Feb. 22-24, 2006.
3. R. Balan, H. V. Poor, S. Rickard, S. Verdu. Time-frequency and time-scale canonical representations of doubly spread channels. EUSIPCO, September 2004.
4. G. Baliga and P.~R.~Kumar, ``A Middleware for Control over Networks,'' Proceedings of the 44th IEEE Conference on Decision and Control, (Invited paper), Seville, Spain, December~2005.
5. G. Baliga, S. Graham, L. Sha, P. R. Kumar. Etherware: Domainware for Wireless Control Networks. Proceedings of the Seventh IEEE International Symposium on Object-Oriented Real-Time Distributed Computing, Vienna, May 2004. pp. 155-162.
6. Louay Bazzi. Minimum Distance of Error Correcting Codes versus Encoding Complexity, Symmetry, and Pseudorandomness. MIT PhD thesis, Laboratory for Information and Decision Systems, September 2003.
7. V. Blondel, J. M. Hendrickx, A. Olshevsky, J. N. Tsitsiklis. Convergence in Multiagent Coordination, Consensus, and Flocking. 2005 IEEE Conference on Decision and Control, December 2005.
8. H. Cai, S. R. Kulkarni, S. Verdu. Universal Estimation of Entropy and Divergence Via Block Sorting. ISIT 2002, January 2002.
9. H. Cai, S. R. Kulkarni, S. Verdu. A Universal Lossless Compressor with Side Information Based on Context Tree Weighting. Proc. IEEE Int. Symp. Inform. Theory, September 2005.
10. G. Caire, D. Tuninetti, S. Verdu. Is TDMA Optimal in the Low Power Regime? Proceedings of International Symposium on Information Theory, 2002.
11. G. Caire, S. Shamai, S. Verdu. Constructive Approaches to Fixed-Length Data Compression. IEEE Int. Symp. Information Theory, July 2003.
12. G. Caire, S. Shamai, S. Verdu. Almost-Noiseless Joint Source-Channel Coding-Decoding of Sources with Memory. 5th International ITG Conference on Source and Channel Coding, January 2004.
13. G. Caire, S. Shamai, A. Shokrollahi S. Verdu. Fountain Codes for Lossless Compression of Binary Sources. IEEE Workshop on Information Theory, San Antonio, October 2004.
14. G. Caire, S. Shamai, and S. Verdu. Practical Schemes for Interactive Data Exchange. 2004 International Symposium on Information Theory and its Applications, October 2004.
15. M. Cetin, D. M. Malioutov, A. S. Willsky. A Variational Technique for Source Localization based on a Sparse Signal Reconstruction Perspective. IEEE International Conference on Acoustics Speech and Signal Processing (ICASSP), vol. 3, May 2002. pp. 2965-2968.
16. L. Chen, M. J. Wainwright, M. Cetin, A.S. Willsky. Data Association based on Optimization in Graphical Models with Application to Sensor Networks. (to appear in:) Mathematical and Computer Modelling, Special Issue on Optimization and Control for Military Applications, (Invited paper).
17. L. Chen, M. J. Wainwright, M. Cetin, A. S. Willsky. Multitarget-Multisensor Data Association Using the Tree-ReweightedMax-Product Algorithm. SPIE Aerosense, April 2003.
18. L. Chen, M. Cetin, A. S. Willsky. Distributed Data Association for Multi-Target Tracking in Sensor Networks. Information Fusion 2005, July 2005.
19. L. Chen, M. Cetin, A. S. Willsky. Graphical Model-based Algorithms for Data Association in Distributed Sensing (Presentation). The Thirteenth Annual Workshop on Adaptive Sensor Array Processing, Lincoln Lab, MIT, June 2005.
20. M. Chu, S. Mitter , F. Zhao. An Information Architecture for Distributed Inference in Ad Hoc Sensor Networks. 41st Annual Allerton Conference on Communication, Control, and Computing, November 2003.
21. M. Chu, S. Mitter , F. Zhao. Distributed Multiple Target Tracking and Data Association in Ad Hoc Sensor Networks. 6th Internatinal Conference on Information Fusion, July 2003.
22. Maurice Chu. A Hierarchical Framework for Constructing Computationally Efficient Algorithms for Distributed Inference Problems. MIT PhD thesis, Laboratory for Information and Decision Systems, February 2003.
23. A. Corduneanu, T. Jaakkola. Stable mixing of complete and incomplete information. MIT AI Memo AIM-2001-030, November 2001.
24. A. Corduneanu, T. Jaakkola. Continuation Methods for Mixing Heterogeneous Sources. Proceedings of the Eighteenth Annual Conference on Uncertainty in Artificial Intelligence, May 2002.
25. A. Corduneanu, T. Jaakkola. On Information Regularization. UAI 03, (best paper award), March 2003.
26. A. Corduneanu, T. Jaakkola. Distributed Information Regularization on Graphs. Advances in Neural Information Processing Systems, 17, June 2004.
27. J.W. Fisher III, Alexander T. Ihler, Paul Viola. Learning Informative Statistics: A Nonparametric Approach. Advances in Neural Information Processing Systems, 12, December 1999. pp. 900-906.
28. J.W. Fisher III, Trevor Darrell, William Freeman, Paul Viola. Learning Joint Statistical Models for Audio-Visual Fusion and Segregation. Advances in Neural Information Processing Systems, 13, December 2000.
29. J.W. Fisher III, Trevor Darrell. Signal Level Fusion for Multimodal Perceptual User Interface. Workshop on Perceptive User Interfaces, October 2001.
30. J.W. Fisher III, Trevor Darrell. Informative subspaces for audio-visual processing: high-level function from low-level fusion. ICASSP,

May 2002.
31. J.W. Fisher III, Trevor Darrell. Probabilistic models and informative subspaces for audiovisual correspondence. European Conference on Computer Vision, volume III, June 2002. Page 592.
32. E. Fox. Detection and Localization of Aerosol Releases from Sparse Sensor Measurements. MIT MEng thesis, Laboratory for Information and Decision Systems, June 2005.
33. P. Frey, R., Jaakkola, T., Moran J. Sequentially Fitting Inclusive Trees for Inference in Noisy-OR Networks. Advances of Neural Information Processing Systems, 13, November 2000.
34. A. Fu, E. Modiano, J.N. Tsitsiklis. Optimal Energy Allocation for Delay-Constrained Data Transmission over a Time-Varying Channel. Proceedings of the 2003 INFOCOM, 2003.
35. A. Giridhar, P. R. Kumar. Computing and Communicating Statistics in Sensor Networks. Proceedings of 2004 IEEE International Symposium on Information Theory, Chicago, June 2004. pp. 80.
36. A. Giridhar, P. R. Kumar. Scheduling Algorithms for Automated Traffic. Proceedings of the 43rd IEEE Conference on Decision and Control, Bahamas , December 2004. pp. 2754-2759.
37. A. Giridhar, P. R. Kumar. Sensor networks: Towards a theory of computation and communication of functions of measurements to a fusion center. Proceedings of 2004 International Zurich Seminar on Communications, Zurich (invited paper), February 2004. pp. 176-178.
38. S. Graham, P. R. Kumar. The Convergence of Control, Communication, and Computation. Proceedings of PWC 2003: Personal Wireless Communication; Lecture Notes in Computer Science, Volume 2775/2003, Springer-Verlag, Heidelberg, 2003, (invited paper), September 2003. pp. 458-475.
39. Guo, S. Shamai, and S. Verdu. Mutual Information and Conditional Mean Estimation in Poisson Channels. 2004 IEEE Workshop on Information Theory, October 2004.
40. Guo, S. Shamai, S. Verdu. Mutual Information and MMSE in Gaussian Channels. Proceedings of 2004 IEEE International Symposium on Information Theory, Chicago, July 2004.
41. Piyush Gupta, P. R. Kumar. A system and traffic dependent adaptive routing algorithm for ad hoc networks. Proceedings of the 36th IEEE Conference on Decision and Control, December 1997. pp. 2375-2380.
42. P. Gupta, R. Gray, P. R. Kumar. An Experimental Scaling Law for Ad Hoc Networks. ACM Intenational Symposium on Mobile Ad Hoc Networking and Computing (Mo-biHoc 2001), October 2001.
43. Piyush Gupta, P. R. Kumar. Towards an Information Theory of Large Networks: An Achievable Rate Region. Proceeding of the 2001 IEEE International Symposiumon Information Theory, Washington DC, June 2001.
44. M. Gursoy, H. V. Poor, S. Verdu. Power Efficiency of Joint Frequency-Phase Modulation in the Low-SNR Regime over Noncoherent Rician Channels. VTC F04 Transmission Technology, September 2004.
45. M. Gursoy, H. V. Poor, S. Verdu. Spectral Efficiency of Peak Power Limited Rician Block-Fading Channels. Proceedings of 2004 IEEE International Symposium on Information Theory, Chicago, July 2004.
46. M. Gursoy, H. V. Poor and S. Verdu. The Capacity and Power Efficiency of OOFSK Signaling over Wideband Fading Channels. 2004 IEEE Globecom, December 2004.
47. A. Ihler, J. W. Fisher III, A. S. Willsky. Message Errors in Belief Propagation. Advances in Neural Information Processing Systems, December 2004.
48. A. Ihler, J. W. Fisher III, A. S. Willsky. Particle filtering under communications constraints. IEEE Workshop on Statistical Signal Processing, July 2005.
49. Alexander Ihler. Maximally Informative Subspaces: a Nonparametric Approach. MS Thesis, September 2000.
50. A. Ihler, J. Fisher, A. S. Willsky. Nonparametric Estimators for Online Signature Authentication. ICASSP 2001, May 2001.
51. A. Ihler, E. B. Sudderth, W. T. Freeman, A. S. Willsky. Efficient Multiscale Sampling from Products of Gaussian Mixtures. NIPS, December 2003.
52. A. Ihler, J. W. Fisher, A. S. Willsky. Hypothesis testing over factorizations for data association. IPSN, April 2003.
53. A. Ihler, J. W. Fisher III, R. L. Moses, A. S. Willsky. Nonparametric Belief Propagation for Self-Calibration in Sensor Networks. IPSN, April 2004.
54. A. Ihler, J. W. Fisher III, R. L. Moses, A. S. Willsky. Nonparametric Belief Propagation for Sensor Self-Calibration. ICASSP, May 2004.
55. T. Jaakkola, H. Siegelmann. Active information retrieval. Advances in Neural Information Processing Systems, January 2002.
56. J.K. Johnson, E. Sudderth, D. Tucker, M. Wainwright, A.S. Willsky. Multiresolution and Graphical Models for Images and Spatial Data. MiniSymposium on Bayesian Hierarchical Statistical Models for Analysis of Images, SIAM Conference on Imaging Science, March 2002.
57. J.K. Johnson. Estimation of GMRFs by Recursive Cavity Modeling. Masters Thesis, MIT, March 2003.
58. J.K. Johnson, D.M. Malioutov, A.S. Willsky. Walk-Sum Interpretation and Analysis of Gaussian Belief Propagation. NIPS, June 2005.
59. A. Jovicic, S.R. Kulkarni, P. Viswanath. Upper Bounds to Transport Capacity in Wireless Networks. 42nd IEEE Conference on Decision and Control, December 2003.
60. V. Kawadia, S. Narayanaswamy, R. Rozovsky, R. S. Sreenivas P. R. Kumar. Protocols for Media Access Control and Power Control in Wireless Networks. Proceedings of the 40th IEEE Conference on Decision and Control, December 2001. pp. 1935-1940.

61. Vikas Kawadia, P. R. Kumar. Power Control and Clustering in Ad Hoc Networks. Proceedings of INFOCOM 2003, San Francisco, March 2003.
62. V. Kawadia, P. R. Kumar. Experimental Investigations into TCP Performance over Wireless Multihop Networks. ACM Workshop on Experimental Approaches to Wireless Network Design and Analysis (E-WIND 2005), August 2005.
63. O. P. Kreidl, M. Cetin, A. S. Willsky. Collaborative Distributed Inference with Minimal Online Communication. The Learning Workshop at Snowbird , April 2005.
64. S.R. Kulkarni, P. Viswanath. A Deterministic View of Throughput Scaling in Wireless Networks. Proc. International Symposium on Information Theory, July 2002.
65. S.R. Kulkarni, P. Viswanath. Throughput Scaling in Heterogeneous Networks. Proceedings of the 2003 IEEE International Symposium on Information Theory, Yokohama, July 2003.
66. P. R. Kumar. Issues in Ad Hoc Networks: Scaling laws, Media Access Control and Power Control (Keynote Talk). Proceedings of ITCom 2001: The convergence of Information Technologies and Communication, Denver, August 2001. pp. 14-21.
67. P. R. Kumar. The Distributed Nonlinear Stocastic World of Networks. Proceedings of the IUTAM Symposium; Control of Stochastic Systems, Kluwer Academic Publishers, Dordrecht, The Netherlands, Montecello, IL, August 2002. pp. 205-216.
68. P. R. Kumar. Wireless Networks: Analysis, Protocols, Architecture, and Towards Convergence. Proceedings of WiOpt 2003: Modeling and Optimization in Mobile and Ad Hoc and Wireless Networks, Sophia Antipolis, France (Plenary Talk), March 2003. pp. 19-24.
69. P.R. Kumar. Capacity, Architecture, Protocols, and Sensing in Wireless Networks. Proceedings of the 2004 IEEE Information Theory Workshop, October 2004. pp. 469-472.
70. L. Li, A. Tulino, S. Verdu. Design of MMSE Multiuser Detectors using Random Matrix Techniques. IEEE Int. Conference on Communications, May 2003.
71. A. Lozano, A. Tulino, S. Verdu. Correlation number: a new design criterion in multi-antenna communication. Vehicular Technology Conference, April 2003.
72. A. Lozano, A. Tulino, S. Verdu. Multiantenna Capacity in Interference Limited Low-Power Conditions. IEEE Int. Symp. Information Theory, July 2003.
73. A. Lozano, A. Tulino, S. Verdu. High-SNR Power Offset in Multi-Antenna Communication. Proceedings of 2004 IEEE International Symposium on Information Theory, Chicago, July 2004.
74. A. Lozano, A. Tulino, S. Verdu. Power Allocation in Multi-Antenna Communication with Statistical Channel Information at the Transmitter. 15TH IEEE Int. Symp. on Personal, Indoor and Mobile Radio Communications, Barcelona, September 2004.
75. A. Lozano, S.R. Kulkarni, P. Viswanath. Throughput Scaling in Wireless Networks with Restricted Mobility. Proceedings of 2004 IEEE International Symposium on Information Theory, Chicago, July 2004.
76. A. Lozano, A. Tulino and S. Verdu. High-SNR Power Offset in Multi-Antenna Ricean Channel. 2005 IEEE Int. Conf. Communications, May 2005.
77. A. Lozano, A. Tulino and S. Verd\'{u}. Mercury/Waterfilling for Fixed Wireless OFDM Systems. IEEE Radio and Wireless Symposium (RWS) (invited paper), San Diego, CA, Jan. 17-19, 2006.
78. D.M. Malioutov, M. Cetin, J. W. Fisher III, Alan S. Willsky. Super-resolution source localization through data-adaptive regularization. IEEE Sensor Array and Multichannel Signal Processing Workshop, August 2002.
79. D.M. Malioutov, M. Cetin, J. W. Fisher III, Alan S. Willsky. Super-resolution source localization through data-adaptive regularization. Adaptive Sensor Array Processing Workshop, March 2002.
80. D.M. Malioutov, M. Cetin, A. S. Willsky. Source Localization by Enforcing Sparsity through a Laplacian Prior: an SVD-based Approach. IEEE Statistical Signal Processing Workshop, October 2003.
81. D.M. Malioutov. A Variational Approach to Array Processing in the Presence of Uncertainties. MIT Masters Thesis, May 2003.
82. D.M. Malioutov, M. Cetin, A. S. Willsky. Optimal Sparse Representations in general overcomplete Bases. ICASSP, 2004.
83. D.M. Malioutov, M. Cetin, A. S. Willsky. Homotopy Continuation for sparse signal representation. ICASSP 2005, 2005.
84. S. Mannor, J. N. Tsitsiklis. Lower Bounds on the Sample Complexity of Exploration in the Multi-Armed Bandit Problem. COLT 2003, LNAI 2777, B. Scholkopf and M.K. Warmuth (Eds.), Springer, August 2003. pp. 418-443.
85. S. Mannor, R. Rubinstein, Y. Gat. The Cross Entropy method for Fast Policy Search. Twentieth International Conference on Machine Learning, August 2003. pp. 512-519.
86. M. Meila, Jaakkola, T. Tractable Bayesian Learning of Tree Belief Networks. Sixteenth Annual Conference on Uncertainty in Artificial Intelligence, December 2000.
87. S.K. Mitter. Control with Limited Information: the Role of Systems Theory and Information Theory. IEEE Information Theory Society Newsletter, vol. 50, December 2000. pp. 1-23.
88. C. Monteleoni, T. Jaakkola. On-line learning of non-stationary sequences. NIPS 03, June 2003.
89. S. Narayanaswamy, Vikas Kawadia, R. S. Sreenivas, P. R. Kumar. Power Control in Ad-Hoc Networks: An Architectural Solution for a Melee of Multiple Agents, Cost Criteria, and Information Patterns. Symposium on Complex Systems Modeling and Optimization in the Information Age to Celebrate 45 Years of Outstanding Contribution of Prof.\ Yu-Chi "Larry" Ho, June 2001.
90. S. Narayanaswamy, Vikas Kawadia, R. S. Sreenivas, P. R. Kumar. Power Control in Ad-Hoc Networks: Theory, Architecture, Algorithm and Implementation of the COMPOW protocol. Proceedings of European Wireless Conference -- Next Generation Wireless

Networks: Technologies, Protocols, Services and Applications, Florence, February 2002. pp. 156-162.
91. Ordentlich, G. Seroussi, S. Verdu, K. Viswanathan, M. Weinberger, T. Weissman. Channel decoding of systematically encoded unknown redundant sources. Proceedings of 2004 IEEE International Symposium on Information Theory, Chicago, July 2004.
92. D.P. Palomar and S. Verd\'{u}. Estimation-Theoretic Representation of Mutual Information. Forty-third Annual Allerton Conference on Communication, Control, and Computing, Monticello, IL, Sep. 28-30, 2005.
93. D.P. Palomar and S. Verd\'{u}. Lautum Information. IEEE Information Theory Workshop, (invited paper) Punta del Este, Uruguay, Mar. 2006
94. Kurt Plarre, P. R. Kumar. Gaussian inference in loopy graphical models. Proceedings of the 42nd IEEE Conference on Decision and Control, Maui, December 2003. pp. 5747-5752.
95. Kurt Plarre, P. R. Kumar, T. I. Seidman. Increasingly Correct Message Passing Algorithms for Heat Source Detection in Sensor Networks. Proceedings of The First IEEE International conference on Sensor and Ad hoc communications and networks (SECON 2004), Santa Clara, October 2004.
96. J. Predd, S.R. Kulkarni, H.V. Poor. Consistency in a Model for Distributed Learning. Proceedings of 2004 IEEE International Symposium on Information Theory, Chicago, July 2004.
97. J. Predd, S.R. Kulkarni, H.V. Poor. Consistency in Models for Communication Constrained Distributed Learning. Proc. 17th Annual Conference on Learning Theory, COLT 2004, Canada, July 2004.
98. R. J. Radke, P. J. Ramadge, S. R. Kulkarni, T. Echigo, S. Iisaku. Recursive Propagation of Correspondences with Applications to the Creation of Virtual Video. IEEE International Conference on Image Processing, September 2000. pp. 250-253.
99. Vivek Raghunathan, P.R. Kumar. A Wardrop routing protocol for ad hoc wireless networks. Proceedings of the 43rd IEEE Conference on Decision and Control, Bahamas, December 2004. pp. 4661-4666.
100. V. Raghunathan, P. R. Kumar. Issues in Wardrop Routing in Wireless Networks. Proceedings of the First International Wireless Internet Conference (WICON 2005), February 2005.
101. A. Reznik, S. R. Kulkarni, S. Verdu. Capacity and Optimal Resource Allocation in the Degraded Gaussian Relay Channel with Multiple Relays. Proceedings of 40th Allerton Conference on Communications, Control and Computing, October 2002.
102. A. Reznik, S.R. Kulkarni, S. Verdu. Scaling Laws in Random Heterogeneous Networks. Proceedings of 2004 IEEE International Symposium on Information Theory, Chicago, July 2004.
103. A. Reznik, S.R. Kulkarni, S. Verdu. Broadcast-relay channel: Capacity Region Bounds. Proc. 2005 Int. Symp. on Information Theory, 2005.
104. C.L. Robinson, G. Baliga, S. Graham, P. R. Kumar. Design Patterns for Robust and Evolvable Networked Control. Proceedings of the Third Annual Conference on Systems Engineering Research (CSER 2005), March 2005.
105. A. Roumy, S. Guemghar, G. Caire, S. Verdu. Design Methods for Irregular Repeat-Accumulate Codes. IEEE International Symposium on Information theory, July 2003.
106. R. Rozovsky, P. R. Kumar. SEEDEX: A MAC protocol for ad hoc networks. Proceedings of The 2001 ACM Intenational Symposium on Mobile Ad Hoc Networking and Computing, (MobiHoc 2001), October 2001. pp. 67-75.
107. A. Sahai. Anytime Information Theory. Ph.D. Thesis, MIT, January 2001.
108. S. Sandilya, S. R. Kulkarni. Principal Curves With Bounded Turn. Proceedings of the International Symposium on Information Theory, June 2000. pp. 321-0.
109. M. Siracusa, Estimating Dependency and Significance for High-Dimensional Data. International Conference on Acoustics, Speech and Signal Processing, M. Siracusa, K. Tieu, A.T. Ihler, J.W. Fisher, A.S. Willsky, March 2005. pp. 1085-1088.
110. N. Srebro, J. Rennie, and T. Jaakkola. Maximum margin matrix factorization. Advances in Neural Information Processing Systems, 17, 2004.
111. Nathan Srebro, T. Jaakkola. Generalized Low-Rank Approximations. ICML 03, February 2003.
112. Nathan Srebro, T. Jaakkola. Linear dependent dimensionality reduction. Advances in Neural Information Processing Systems, 16, 2003.
113. Nathan Srebro, T. Jaakkola. Towards Dependent Dimensionality Reduction: Linear Dependence and Additive Noise. NIPS 03, June 2003.
114. N. Srebro, N. Alon, and T. Jaakkola. Generalization Error Bounds for Collaborative Prediction with Low-Rank Matrices. Advances in Neural Information Processing Systems, 17, 2004.
115. Erik Sudderth, A. T. Ihler, W. T. Freeman, A. S. Willsky. Nonparametric Belief Propagation. MIT LIDS Technical Report 2551, October 2002.
116. Erik Sudderth. Embedded Trees: Estimation of Gaussian Processes on Graphs with Cycles. MIT Masters Thesis, February 2002. pp. 1-164.
117. Erik Sudderth, M. J. Wainwright, A. S. Willsky. Embedded Trees: Estimation of Gaussian Processes on Graphs with Cycles. MIT LIDS Technical Report P-2562, April 2003.
118. Erik Sudderth, A. T. Ihler, W. T. Freeman, A. S. Willsky. Nonparametric Belief Propagation. IEEE Conference on Computer Vision and Pattern Recognition, June 2003.
119. E. Sudderth, M. I. Mandel, W. T. Freeman, A. S. Willsky. Distributed Occlusion Reasoning for Tracking with Nonparametric Belief

Propagation. Advances in Neural Information Processing Systems, December 2004.
120. E. Sudderth, M. I. Mandel, W. T. Freeman, A. S. Willsky. Visual Hand Tracking Using Nonparametric Belief Propagation. IEEE CVPR Workshop on Generative Model Based Vision, June 2004.
121. M. Szummer, T. Jaakkola. Partially labeled classification with Markov random walks. Advances in Neural Information Processing Systems, 14, January 2002.
122. Dewey S. Tucker. Multiresolution Modeling from Data and Partial Specifications. MIT Ph.D. Thesis, December 2004.
123. A. Tulino, A. Lozano, S. Verdu. MIMO Capacity with Channel State Information at the Transmitter. 2004 IEEE International Symposium on Spread Spectrum Techniques and Applications, Sydney, September 2004.
124. A. Tulino, S. Verdu. The Shannon Transform in Random Matrix Theory. Bernoulli Society/IMS Congress, July 2004.
125. A. Tulino, S. Verdu. Asymptotic Outage Capacity of Multiantenna Channels. 2005 IEEE Int. Conf. Acoustics, Speech and Signal Processing, March 2005.
126. S.R. Venkatesh, S.K. Mitter. Statistical Estimation and Modeling with Finite Data. ISIT Conference, Lausanne, Switzerland, July 2002.
127. S. Verdu. Error correcting codes and data compression. DIMACS Workshop on Algebraic Coding Theory and Information Theory Workshop, Rutgers University , December 2003.
128. S. Verdu. Connections between Estimation Theory and Information Theory. Information Systems Seminar, Dept. Electrical Engineering, Stanford University, May 2004.
129. S. Verdu. Connections between MMSE Estimation and Information Theory. Proceedings of 2004 International Zurich Seminar on Communications, Zurich (invited keynote address), February 2004.
130. S. Verdu. Estimation Theory and Information Theory: New Connections. 2nd International Workshop on Signal Processing for Wireless Communications, London (invited plenary talk), June 2004.
131. S. Verdu. Physical Channel Research: The Road Ahead. 15TH IEEE Int. Symp. on Personal, Indoor and Mobile Radio Communications, Barcelona (invited keynote speech), September 2004.
132. S. Verdu. The Interplay between Mutual Information and MMSE. IEEE Communication Theory Workshop, Capri, May 2004.
133. S. Verdu. The Interplay between Mutual Information and MMSE. Dipartimento de Elettronica, Politecnico di Torino, Torino, Italy, May 2004.
134. K. Visweswariah, S. R. Kulkarni, S. Verdu. Output Distribution of the Burrows Wheeler Transform. Proc. Int\\'l Symposium on Information Theory, June 2000. pp. 53-53.
135. M. J. Wainwright, E. P. Simoncelli, A. S. Willsky. Random cascades of Gaussian scale mixtures and their use in modeling natural images with application to denoising. IEEE 7th International Conference on Image Processing, September 2000.
136. M. J. Wainwright, E. P. Simoncelli, A. S. Willsky. Random cascades on wavelet trees and their use in analyzing and modeling natural images. 45th Annual Meeting of the SPIE, July 2000.
137. M. J. Wainwright, E. Sudderth, A. S. Willsky. Tree-based modeling and estimation of Gaussian processes on graphs with cycles. Advances in Neural Information Processing Systems, November 2000.
138. M. Wainwright, T.S. Jaakkola, A.S. Willsky. A new class of upper bounds on the log-partition function. Snowbird Workshop on Learning, Snowbird, UT, April 2002.
139. M. Wainwright, T.S. Jaakkola, A.S. Willsky. A new class of upper bounds on the log-partition function. Uncertainty in Artificial Intelligence, 2002.
140. Martin Wainwright, T.S. Jaakkola, A.S. Willsky. MAP estimation via agreement on (hyper)trees: Message-passing and linear programming approaches. Allerton Conference on Communication, Control and Computing, October 2002.
141. Martin Wainwright, T. Jaakkola, A. Willsky. Tree-based reparameterization for approximate estimation of stochastic processes on graphs with cycles. Int'l. Symposium on Information Theory, Lausanne, Switzerland, July 2002.
142. Martin Wainwright, T. Jaakkola, A. Willsky. Tree-based reparameterization for approximate inference on loopy graphs. Advances in Neural Information Processing Systems, 2002.
143. Martin Wainwright. Stochastic processes on graphs with cycles: Geometric and variational approaches. MIT PhD thesis, Laboratory for Information and Decision Systems, January 2002.
144. Martin Wainwright, T. Jaakkola, A. Willsky. Tree-reweighted belief propagation algorithms and approximate ML estimation by pseudo-moment matching. Workshop on Artificial Intelligence and Statistics, January 2003.
145. C.-C. Wang, S.R. Kulkarni, H.V. Poor. Bandit Problems With Side Information. 41st IEEE Conference on Decision and Control, December 2002.
146. C.-C. Wang, S.R. Kulkarni, H.V. Poor. Arbitrary Side Observations in Bandit Problems. 42nd IEEE Conference on Decision and Control, December 2003.
147. C.-C. Wang, S.R. Kulkarni, H.V. Poor. Density Evolution for Asymmetric Memoryless Channels. 3rd International Symposium on Turbo Codes and Related Topics, Brest, France, September 2003.
148. C. Wang, S.R. Kulkarni, H.V. Poor. On Finite-Dimensional Bounds for LDPC-like Codes with Iterative Decoding. IEEE Int. Symp. Inform. Theory \& Its Appl., October 2004.
149. C. Wang, S.R. Kulkarni, H.V. Poor. On the typicality of the linear code among the LDPC coset code ensemble. 39th Conf. Inform.

Sciences and Systems, March 2005.
150. Q. Wang, S. Kulkarni and S. Verdu. Universal Estimation of Divergence for Continuous Distributions via Data-Dependent Partitions. IEEE International Symposium, September 2005.
151. T. Weissman, E. Ordentlich, G. Seroussi , S. Verdu, M. Weinberger. Universal Discrete Denoising: Known Channel. IEEE Int. Symp. Information Theory, July 2003.
152. J. Williams, J.W. Fisher III, A.S. Willsky. An Approximate Dynamic Programming Approach for Communication Constrained Inference. IEEE Workshop on Statistical Signal Processing, July 2005.
153. J. Williams, J.W. Fisher III, A.S. Willsky. An Approximate Dynamic Programming Approach to a Communication Constrained Sensor Management Problem. Eighth International Conference of Information Fusion, July 2005.
154. J. Williams, J.W. Fisher III, A.S. Willsky. Optimization Approaches to Dynamic Routing of Measurements and Models in a Sensor Network Object Tracking Problem. International Conference on Acoustics, Speech and Signal Processing, March 2005. pp. 1061-1064.
155. L.-L. Xie, P. R. Kumar. New Results in Network Information Theory: Scaling Laws and Optimal Operational Modes for Wireless Networks. Proceedings of 41st IEEE Conference on Decision and Control, Las Vegas, December 2002. pp. 3205-3208.
156. L.-L. Xie, P. R. Kumar. New Results in Network Information Theory: Scaling Laws for Wireless Communication and Optimal Strategies for Information Transport. Proceedings of 2002 IEEE Information Theory Workshop, Bangalore, October 2002. pp. 24.
157. L.-L. Xie, P. R. Kumar. Network Information Theory for Wireless Communications. Proceedings of the 2003 IEEE International Symposium on Information Theory, Yokohama, July 2003. p. 288.
158. L.-L. Xie, P. R. Kumar. An achievable rate for the multiple-level relay channel. Proceedings of 2004 IEEE International Symposium on Information Theory, Chicago, June 2004. pp. 3.
159. L.-L. Xie, P. R. Kumar. Wireless Network Information Theory. in Advances in Network Information Theory, DIMACS Series in Discrete Mathematics and Computer Science, Proceedings of the DIMACS Workshop on Network Information Theory, P. Gupta, G. Kramer, A.J. van Wijngaarden (Eds.),
160. American Mathematical Society, Rhode Island, USA., vol. 66, March 2004. pp. 151-158.
161. Xue, L-L. Xie, P. R. Kumar. The Transport Capacity of Wireless Networks over Fading Channels. Proceedings of 2004 IEEE International Symposium on Information Theory, Chicago, June 2004. pp. 370.
162. J. Yu, S. Verdu. Schemes for Bi-Directional Modeling of Discrete Stationary Sources. 2005 Conference on Information Sciences and Systems, March 2005.

Number of Papers published in non peer-reviewed journals: 162.00

(c) Papers presented at meetings, but not published in conference proceedings (N/A for none)

Number of Papers not Published: 0.00

(d) Manuscripts

1. G. Baliga, P. R. Kumar. Middleware for Control over Networks. submitted to Proceedings of the 44th IEEE Conference on Decision and Control (Invited paper), March 2005.
2. L. Bazzi, S.K. Mitter. Some constructions of codes from group actions. submitted to IEEE Trans. on Information Theory, also MIT LIDS Publication 2531, March 2003.
3. A. Corduneanu, T. Jaakkola. Information and transductive estimation. submitted, 2005.
4. A. Ganti, E. Modiano, J. N. Tsitsiklis. Optimal Transmission Scheduling in Symmetric Communication Models with Intermittent Connectivity. submitted to IEEE Transactions on Information Theory, July 2004.
5. A. Giridhar and P.~R.~Kumar, ``Scheduling Traffic on a Network of Roads," To appear in \emph{IEEE Transactions on Vehicular Technology}, May 2006.
6. Ramesh Johari, S. Mannor, J. N. Tsitsiklis. A Contract-Based Model for Directed Network Formation. to appear in Games and Economic Behavior, submitted November 2003.
7. O. P. Kreidl, M. Cetin, A. S. Willsky. A Message-Passing Algorithm for Optimizing Decentralized Detection Networks. submitted to 44th IEEE Conference on Decision and Control, 2005.
8. D. M. Malioutov, M. Cetin, A. S. Willsky. A Sparse Signal Reconstruction Perspective for Source Localization with Sensor Arrays. IEEE Transactions on Signal Processing (in review).
9. K. Plarre, P. R. Kumar. Object Tracking by Scattered Directional Sensors. Proceedings of the 44th IEEE Conference on Decision and Control (Invited paper), December 2005.
10. R. Radke, P. Ramadge, S. Kulkarni, T. Echigo. Efficiently Synthesizing Virtual Video. submitted to IEEE Transactions on Circuits and Systems for Video Technology, January 2002.
11. V. Raghunathan, P. R. Kumar. A counterexample in congestion control of wireless networks. Proc. of the 8-th ACM/IEEE International Symposium on Modeling, Analysis and Simulation of Wireless and Mobile Systems (MSWIM 2005), October 2005.
12. Alex Reznik, S. Verdu. On the Transport Capacity of a Broadcast Gaussian Channel. submitted to Communications in Information and Systems, 2002.
13. A. Sahai and S.K. Mitter. The Necessity and Sufficiency of Anytime Capacity for Stabilization of a Linear System Over a Noisy Communication Link, Part I: Scalar Systems. submitted to IEEE Trans. on Info. Theory, May 2005.
14. A. Sahai and S.K. Mitter. The Necessity and Sufficiency of Anytime Capacity for Stabilization of a Linear System Over a Noisy Communication Link, Part II: Vector System, submitted to IEEE Trans. on Info. Theory, May 2005.
15. S. Tatikonda, S. K. Mitter. The Capacity of Channels with Feedback, Part I: the General Case. submitted to IEEE Trans. on Info. Theory, October 2001.
16. M. Wainwright, T. Jaakkola, A. Willsky. Tree-based reparameterization for approximate estimation of stochastic processes on graphs with cycles. submitted to IEEE Trans. on Info. Theory, September 2001.
17. M. Wainwright, T.S. Jaakkola, A.S. Willsky. A new class of upper bounds on the log-partition function. submitted to IEEE Trans. on Info. Theory, 2002.
18. M. Wainwright, T.S. Jaakkola, A.S. Willsky. Tree consistency and bounds on the max-product algorithm. submitted to IEEE Trans. on Info. Theory, 2002.
19. M. Wainwright, T.S. Jaakkola, A.S. Willsky. Tree reweighted max-product algorithm and its properties. submitted to IEEE Trans. on Info. Theory, 2002.

Number of Manuscripts: 19.00

Number of Inventions:

Graduate Students

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Names of Post Doctorates

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Names of Faculty Supported

NAME PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Under Graduate students supported

NAME PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Personnel receiving masters degrees

NAME

Total Number:

Names of personnel receiving PHDs

NAME

Total Number:

Names of other research staff

NAME PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Sub Contractors (DD882)

Inventions (DD882)

A COMPREHENSIVE APPROACH TO FUSION FOR MICROSENSOR NETWORKS: DISTRIBUTED AND HIERARCHICAL INFERENCE, COMMUNICATION, AND ADAPTATION

Final Report for the MURI on Data Fusion in Large Arrays of Microsensors (SensorWeb)

August 1, 2000 - January 31, 2006

Grant DAAD19-00-1-0466

Alan S. Willsky (MIT)
Sanjoy K. Mitter (MIT)
John W. Fisher, III (MIT)
Mujdat Cetin (MIT)
Tommi Jaakkola (MIT)
John N. Tsitsiklis (MIT)
Sanjeev Kulkarni (Princeton)
Sergio Verdu (Princeton)
P.R. Kumar (Illinois)

Submitted to:

Dr. John Lavery, Senior Program Manager
Modeling of Complex Systems Program
Mathematics Division
Army Research Office
Army Research Laboratory
P.O. Box 12211
Research Triangle Park, NC 27709-2211

FOREWARD

This final report summarizes the research and activities under the ODDR&E MURI on the topic of Data fusion in Large Arrays of Microsensors (SensorWeb). The universities involved in this program are the Massachusetts Institute of Technology (through which the grant is administered), the University of Illinois, and Princeton University. The principal investigators for this grant are Prof. Alan Willsky (MIT), Prof. Sanjoy Mitter (MIT), Prof. Sanjeev Kulkarni (Princeton), Prof. P.R. Kumar (Illinois), and Prof. Tommi Jaakkola (MIT).

In recent years there has been an emergence of a number of new sensing concepts, many of which involve inexpensive and small sensors that can, in principle, be deployed in large numbers to provide enhanced spatio-temporal sensing coverage in ways that are either prohibitively expensive or impossible using conventional sensing assets. Realizing the potential of such large, distributed sensor systems, however, requires major advances in the theory and fundamental understanding of distributed data fusion in highly uncertain environments using sensing/communications nodes that are severely constrained in computation and communication capabilities. The overall goal of this MURI is to further this basic theory and understanding by addressing problems including: consistent fusion algorithms for networked sensors; adaptive collaborative processing in highly uncertain environments; and transmission of information in large and uncertain networks. Other major goals of this program are the training of graduate students and post-doctoral associates so that they are equipped to tackle multidisciplinary challenges such as those embedded in the SensorWeb concept and to communicate our ideas and results to others in the DoD community to further efforts aimed at realizing the potential of microsensor arrays.

During this program, we have had considerable success in every dimension of our efforts: in producing fundamental advances to the intellectual challenges presented by the SensorWeb concept; in establishing a leadership position for our team and team members in this very important area; in developing substantive interactions and collaborations with other academic research efforts including MURI's in related areas; in pursuing and establishing partnerships with industrial and DoD R&D activities which have already led to several transitions of our work; and in training a substantial group of young researchers who have contributed to our successes and who are now poised to become research leaders in their own right. In this report we describe the major themes of our research and provide brief summaries of our research, highlighting key results; describe our interactions and collaborations with academia and with our industrial and DoD partners; provide a prospective look at our vision for the future; and include factual information on personnel, publications and presentations. Further details about all activities associated with this MURI can be found on our website: http://sensorweb.mit.edu

Contents

1 INTRODUCTION

This final report summarizes the research and activities under the ODDR&E MURI on the topic of Data fusion in Large Arrays of Microsensors (SensorWeb). The universities involved in this program are the Massachusetts Institute of Technology (through which the grant is administered), the University of Illinois, and Princeton University. The principal investigator for this grant is Prof. Alan Willsky (MIT). Prof. Willsky is joined in leading this program by Prof. Sanjoy Mitter (MIT), Prof. Tommi Jaakkola (MIT), Prof. John Tsitsiklis (MIT), Dr. Mujdat Cetin (MIT), Dr. John Fisher (MIT), Prof. P.R. Kumar (Illinois), Prof. Sanjeev Kulkarni (Princeton), and Prof. Sergio Verdu (Princeton).

During this program we have had considerable success in every dimension of our effort. First of all, our research has resulted in fundamental advances in each of the lines of inquiry that make up our program and that span all of the research challenges spelled out in our proposal and in the original call for proposals. Second, we have been quite successful in establishing program infrastructure and internal interactions that have been of immense help both in facilitating our multidisciplinary research and in presenting and promoting the activities of our program. Third, our research has received considerable attention from the academic and broader R&D community, and members of our team have been widely sought for invited talks and papers and have established leadership positions in the community. Fourth, we have established substantive interactions and collaborations with other academic efforts including MURI teams working in related areas. Fifth, we have been active in fostering and developing interactions with industrial and DoD partners, leading even at this early stage to several transitions and establishing a base for much more leveraging of our research in the future. Finally, thanks to this research program, our educational mission has been a resounding success. In particular, this program has played a central role in the training and development of a substantial group of young researchers who not only have contributed to our successes but also are now poised to become multidisciplinary research leaders in their own right.

In this report we provide a brief summary of these activities and accomplishments (and we also refer the reader to Section 3 for a complete list of publications resulting from this program and to our website http://sensorweb.mit.edu) for additional information and descriptions of our research and activities). In the next subsection we briefly discuss our intellectual vision and, in particular, the overlapping intellectual themes of our research program. We also review the research concentration areas that were identified in the original call for proposals for this MURI topic.

Section 1.2 includes some basic factual information, including a list of all personnel who have been involved in this project (and indicating advanced degrees earned while working on this project). As this list makes clear, we have involved a very large number of students, indicating both the impact of this MURI effort on the educational programs at our three universities and the amount of leveraging of MURI funds we have been able to achieve. Section 1.3 then provides a brief summary of our many activities and the impact they are having in the broader intellectual community and our collaborations with and transition to industry and the DoD community. In Section 2, we then present a brief summary of the most important results of our efforts.

1.1 Intellectual Themes and Research Concentration Areas

The overall objective of this program was the investigation and development of innovative concepts and solutions to the challenges presented by the envisioned availability of very large numbers of heterogeneous sensors each of which is limited in sensing capability, power, computation, and communication. These challenges, while motivated here by military applications, are of pervasive importance, as the concept of "ubiquitous" sensing, computing, and control moves from a dream to a reality. True advances toward this vision require cutting across boundaries between functions–sensing, communication, and application (i.e., exploitation of the sensed data)–and also meeting new challenges due to the desire to deploy such systems economically in complex, unknown, and uncertain environments. As a result the boundaries between wireless communications, sensor fusion, computational complexity, and adaptation are at best blurred and more likely obliterated by the demands of this ambitious new vision.

The primary goal of this MURI program was to make fundamental contributions to the foundations of what is truly a new discipline. Thus we have sought not only to develop new results for important problems within this domain but also to seek new formulations that cut across disciplinary boundaries and help to give shape to this emerging field. While we view our efforts holistically, we have found it helpful, for the purposes both of presentation and of organizing our own thoughts, to group the intellectual challenges of this new domain into three interrelated **intellectual themes (IT's):**

IT-1: Consistent (or manageably inconsistent) fusion of networked, myopic sensors. At its basic level, research in this area examines questions of the following type: Given constraints on communication and computation/memory, as well as a complete probabilistic model capturing relationships among sensors and the variables they measure, determine provably good algorithms for the fusion of the available sensor data for the purposes of estimation and detection, and quantify or bound their performance characteristics. This theme interacts strongly with IT-3 to follow as we strive to understand how network information-theoretic constraints, computational capabilities, and fusion algorithm performance interact. This theme also demands investigations captured in IT-2 as we pursue more adaptive fusion solutions that accommodate additional levels of uncertainty and variability that will be the rule rather than the exception in many sensor networks.

IT-2: Fusion and self-organization of heterogeneous sensors in unstructured and uncertain environments. The basic problems of concern in this area involve the fusion of sensor data when the relationships among the signals sensed by different sensors, the character of those signals, and the environment in which they are propagated from source to sensor are uncertain, variable, or simply unknown. Developing solution methods for problems of this type are essential in order to construct network-constrained fusion algorithms (IT-1) that are robust to these uncertainties and that can learn from observed data and then adapt based on what is learned. In addition, the constraints of network communication (IT-3) constrain how such learning or adaptivity can be accomplished. How do we determine which bits are the most important to communicate in order to *learn* what the most important bits are to communicate?

IT-3: Wireless networks, network communication and information theory. One component of this portion of our research agenda is information-theoretic. Given a wireless network and communication capabilities of each of the network nodes, what are the limits on information that can be communicated throughout the network. Such an investigation, which moves us toward the goal of network information theory, is concerned fundamentally with moving bits from multiple origins to various destinations. Developing results along these lines provides what are in essence constraints for the challenges to be met by network-constrainted (IT-1) and robust, adaptive, and self-organizing (IT-2) fusion. This also suggests other problems in which we consider the interaction of communication and fusion directly. That is, the issue of *which* bits are to be moved from one place to another is intricately bound up with the goals and *structure* of fusion–i.e., with the distortion measures of importance in measuring fusion quality *and* with the fact that the fused products *themselves* will be distributed throughout the network (so that, in particular, every transmitter is also a receiver and, in fact is actually a receiver of its own transmission once it is fused with information elsewhere in the network). These ultimate challenges represent areas in which all three of our themes converge.

These three themes represent what we have found to provide a very useful organization of the intellectual agenda of this MURI. An alternate parsing of this agenda–which has varying levels of granularity from intellectually broad to much more narrowly focused–is that found in the original description of this MURI topic. That document spelled out seven **research concentration areas (RCAs).** The following is a list of concise statements of these RCAs (for the full text of each RCA, we refer the interested reader to the original BAA description for this MURI, available on our website); also, after discussion early in this proposal with MURI program manager, Dr. John Lavery of the Army Research Office, RCAs 2 & 3 were grouped together):

RCA-1: Self-calibration

RCA-2&3: Fundamental limits on fusion, network information theory, tradeoffs in local vs global processing

RCA-4: Bounds & characteristics of algorithms to ID minimum resources needed to detect, estimate, track?

RCA-5: Fusion Algorithms

RCA-6: Distributed Algorithms with guarantees on global behavior (both positive & negative!)

RCA-7: Create events/data for experiments and demos

As we describe in Section 2, our research has resulted in significant advances across the entire intellectual landscape covered by these ITs and RCAs. Moreover, while our research focuses primarily on the fundamental mission of a MURI program–namely the investigation of foundational issues and the development of theories and methodologies that address conceptual, theoretical, and technological barriers to realizing the vision of SensorWeb–we also developed partnerships with industry and DoD to produce results that complement and are of real value to the efforts being pursued by our partners.

1.2 Personnel and Infrastructure

In this subsection provide some factual information about our program. In the next subsection we list the personnel that have been or are involved in our efforts. This list includes 17 faculty members; 8 post-doctoral researchers, research scientists, and long-term visitors; and 47 graduate students. A glance at the budget for this grant makes it clear that our effort has been successfully leveraged with a considerable level of additional support, mostly through university support for faculty time and outside fellowships for a number of our students. Moreover, as the number of graduate students makes clear, we have been extremely successful in attracting student interest and in fulfilling the very important educational portion of our mission.

Subsection 1.2.2 then introduces our website, which contains a list of all of our activities, including not only all of the publications listed in Section 3 but also other resources, including other papers of our team that are relevant to the SensorWeb program; listings of our activities including invited talks, seminars and internal courses and seminars that we have developed; and electronic versions of a number of our presentations and invited talks.

1.2.1 Personnel

The principal faculty involved in this research program were:

MIT: Prof. Tommi Jaakkola, Prof. Sanjoy Mitter, Prof. John Tsitsiklis, Prof. Alan Willsky (PI)

Princeton: Prof. Sanjeev Kulkarni, Prof. Sergio Verdu

Illinois: Prof. P.R. Kumar

Additional MIT faculty members involved in this research program are: Prof. Anantha Chandrakasan, Prof. David Forney, Prof. Eric Grimson, Prof. David Staelin, Prof. Vincent Chan, and Prof. Trevor Darrell (Profs. Grimson, Staelin, Chan, and Darrell do not require financial support from this program but are involved because of their allied research activities that provide both synergy and leverage for our ongoing activities).

There are also several post-doctoral researchers, research scientists, and visitors involved in our research program: Dr. Mujdat Cetin (working primarily with Prof. Willsky); Dr. John Fisher (working with Profs. Willsky, Grimson, and Darrell); Dr. Reuben Rabi (working primarily with Prof. Mitter); Dr. Martin Wainwright (working with Profs. Willsky and Jaakkola); Dr. Shie Mannor (working primarily with prof. Tsitsiklis), Dr. Liang-Liang Xie (working with Prof. Kumar); Visiting Professor Hava Siegelmann (working with Profs. Jaakkola and Willsky) and Visiting Scientist Dr. Robert Washburn (working with Prof. Willsky).

Undergraduate students:

1. M. Zhang, MIT (Willsky)

Graduate students:

1. Ashish Agarwal, Illinois (MS 2004)
2. Girish Baliga, Illinois (MS 2002)
3. Louay Bazzi, MIT (Ph.D. 2003)
4. Haixiao Cai, Princeton (Ph.D. 2005)
5. Min Cao, Illinois
6. Constantine Caramanis, MIT (MS 2001, Ph.D. in progress)
7. Aman Chawla, MIT
8. Lei Chen, MIT
9. Maurice Chu, MIT (Ph.D. 2003)
10. Adrian Corduneanu, MIT (MS 2002, PhD expected 2006)
11. Emily Fox, MIT (MS 2005, Ph.D. in progress)
12. Alvin Fu, MIT
13. Arvind Giridhar, Illinois (MS 2002)
14. Major Scott Graham, Illinois (Ph.D. 2004)
15. Piyush Gupta, Illinois
16. Binita Gupta, Illinois (MS 2002)
17. Nitin Gupta, Illinois (MS 2004)
18. Kun Huang, Illinois (Ph.D. 2004)
19. Alexander Ihler, MIT (MS 2000, Ph.D. 2005)
20. Ramesh Johari, MIT (Ph.D. 2004)
21. Jason Johnson, MIT (MS 2003)
22. V. Kawadia, Illinois
23. O. Patrick Kreidl, MIT
24. Aurelie Lozano, Princeton
25. Dmitry Malioutov, MIT (MS 2003)
26. Claire Monteleoni, MIT
27. Amit Nainani, Illinois (MS 2002)
28. Swetha Narayanaswamy, Illinois
29. Alex Olshevsky, MIT

30. Kurt Plarre, Illinois
31. Joel Predd, Princeton
32. R.J. Radke, Princeton
33. Alex Reznik, Princeton (Ph.D. 2005)
34. R. Rozovsky, Illinois
35. S. Sandilya, Princeton
36. Roberto Solis, Illinois
37. Sung-Hyun Son, Princeton
38. Nathan Srebro, MIT (Ph.D. 2004)
39. Erik Sudderth, MIT (MS 2002)
40. Dewey Tucker, MIT
41. K. Visweswariah, Princeton
42. Martin Wainwright, MIT (Ph.D. 2002)
43. Chin-Chun Wang, Princeton
44. Qing Wang, Princeton (MS 2004)
45. Jason Williams, MIT
46. Yan Wu, Illinois (MS 2003)
47. Feng Xue, Illinois

1.2.2 Website

As we have indicated, the website for our MURI program, the home page of which is displayed below, contains information on the principals involved in the program (including links to web pages appropriate for each), on research efforts associated with this MURI, on our industrial partners (with links to their pages), on publications (including, when available, links to online versions of papers and reports), on highlights (including seminars, visits, and publications/presentations of note), and other available resources.

1.3 Activities, Recognition, and Impact

The research that has been supported under this MURI program and which is highlighted and summarized in Section 2, has resulted in a considerable number of successes and indictors of excellence and impact. While we have not filed patents or made formal invention claims, the impact of our work and its recognition as path-breaking are substantial. In this subsection we summarize these indicators of recognition and impact and also describe many of our activities in support of our research and its broad goal of having an impact on the research and DoD communities.

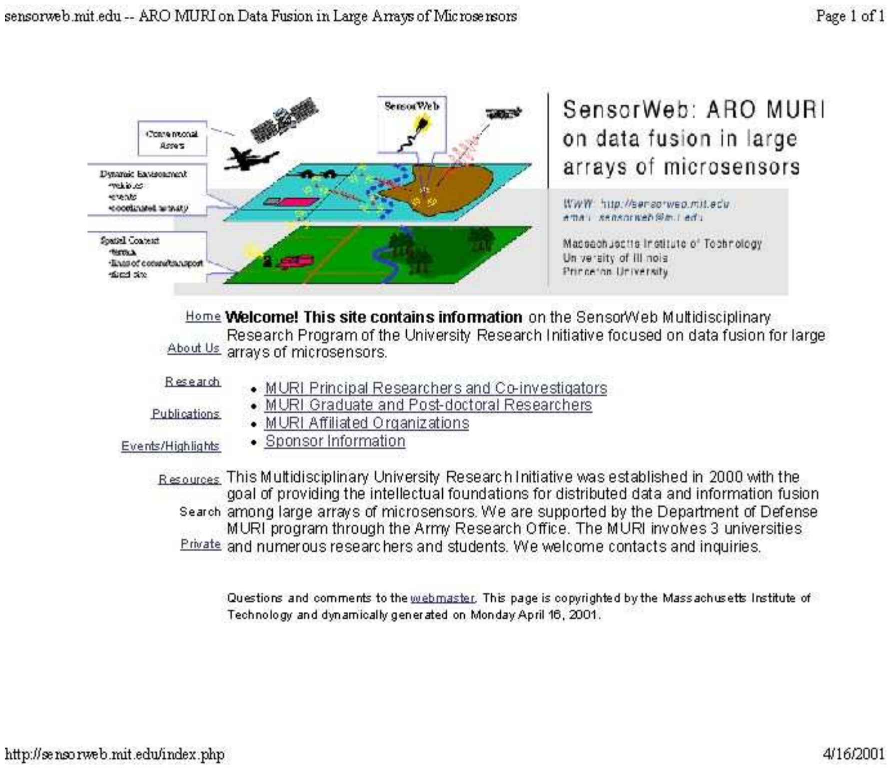

Figure 1: This is a picture of our website.

1.3.1 Invited Presentations, Community Leadership and Awards

Our team has been extremely active in presenting our work at conferences, workshops, and other academic and industrial organizations and in taking leadership roles in organizing such meetings. Our work has been widely recognized within the broad research community, as evidenced by the numerous invited papers and talks, several of which are keynote and plenary presentations, and the many important awards received by members of our team. The following is a listing of these:

1. Graduate student Lei Chen's work on data association for multi-target tracking in sensor networks has received the Best Student Paper Award at the 2005 International Conference on Information Fusion held in Philadelphia, Pennsylvania, on July 25-29, 2005.

2. MIT graduate student Emily Fox received the National Defense Science and Engineering Graduate Fellowship from the Department of Defense as well as the Graduate Research Fellowship from the National Science Foundation.

3. Emily Fox was also awarded the Department of Homeland Security Graduate Fellowship and the Bell Labs Graduate Research Fellowship.

4. Emily Fox won the Chorafas thesis award granted by the Chorafas Foundation for excellent academic performance and superior contributions in research as a Master of

Engineering student and the David Adler Memorial 2nd Place Thesis Prize granted by the MIT EECS department for best master's thesis in electrical engineering.

5. MIT graduate student Alex Ihler received an Outstanding Student Paper Award at the 2004 Neural Information Processing Systems (NIPS) Conference

6. Alex Ihler's work on self-calibration in sensor networks has received the Best Student Paper Prize at the 2004 International Symposium on Information Processing in Sensor Networks, held in Berkeley, California, on April 26-27, 2004.

7. MIT graduate student Adrian Corduneanu received the best paper award at the 18th Conference on Uncertainty in Artificial Intelligence, 2002.

8. Prof. Jaakkola gave an invited lecture on semi-supervised learning in Stanford Universitys Broad Area Colloquium, January 2004.

9. Prof. Kulkarni was elected an IEEE Fellow, 2004.

10. Prof. Kumar received 2006 IEEE Field Award in Control Systems.

11. Prof. Kumar, Keynote Lecture at WCLC 2005, Second World Congress on Lateral Computing, Dec. 16-18th, Bangalore, India. Bangalore.

12. Prof. Kumar, Keynote Talk at *ICISIP, Third International Conference on Intelligent Sensing and Information Processing*, December 14-17, 2005, Bangalore.

13. Prof. Kumar, Keynote Talk at *IFIP Performance 2005*, October 3-7, 2005, Juan Les Pines, France.

14. Prof. Kumar, Plenary Talk at *International Symposium on Information Theory (ISIT)*, University of Adelaide, South Australia, September 4-9, 2005. Title: Towards a theoretical foundation for wireless and sensor networks.

15. Kurt Plarre and P.R. Kumar, "Object Tracking by Scattered Directional Sensors," (to appear in:) *Proceedings of the 44th IEEE Conference on Decision and Control*, Seville, Spain, March 2, 2005.

16. Girish Baliga and P.R. Kumar, "A Middleware for Control over Networks," (to appear in:) *Proceedings of the 44th IEEE Conference on Decision and Control*, Seville, Spain, March 7, 2005.

17. Prof. Kumar gave a Plenary Talk at 39th Annual Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, California, October 30 - November 2, 2005.

18. Prof. Kumar, Keynote Speaker at WICON'05 First International Conference on Wireless Internet, Budapest, Hungary, July 10-15, 2005.

19. Prof. Kumar, Keynote Speaker at IFIP Networking 2005 Conference, University of Waterloo, Ontario, Canada, May 2-6, 2005.

20. Prof. Kumar gave a Plenary Talk at International Symposium on Information Theory (ISIT), University of Adelaide, South Australia, September 4-9, 2005. Title: Towards a theoretical foundation for wireless and sensor networks.

21. Prof. Kumar, Plenary Panel Member at 43rd IEEE Conference on Decision and Control, Paradise Island, Bahamas, December 14-17, 2004.

22. Prof. Kumar gave an Invited Talk at ACM SenSys '04, Baltimore, MD, November 3-5, 2004.

23. Prof. Kumar gave a Plenary Talk at 2004 IEEE Information Theory Workshop, San Antonio, TX, October 24-29, 2004.

24. Prof. Kumar gave the Plenary Talk at The 7th Informs Telecommunication Conference, March 710, 2004, Boca Raton,Florida.

25. Prof. Kumar gave the Plenary Talk at IEEE TENCON'2003, October 15-17, 2003, Bangalore, India.

26. Prof. Kumar gave the Keynote Talk at PWC 2003: The Eighth International Conference on Personal Wireless Communications, September 23-24, 2003, Venice, Italy.

27. Prof. Kumar gave the Plenary Talk at The 2nd International Workshop on Information Processing in Sensor Networks (IPSN '03), April 22-23, 2003, Palo Alto, California, USA.

28. Prof. Kumar gave the Plenary Talk at WiOpt'03: Modeling and Optimization in Mobile and Ad Hoc and Wireless Networks, March 3-5, 2003, Sophia-Antipolis, France.

29. Prof. Kumar gave the Plenary Talk at Annual Workshop On Mobile Information and Communication Systems, February 13, 2003, ETH, Zurich, Switzerland.

30. Prof. Kumar gave the Plenary Talk at the 10th Mediterranean Conference on Control and Automation, Lisbon, Portugal, July 913, 2002.

31. Prof. Kumar gave the Plenary Talk at the German Open Conference on Probability and Statistics, Magdeburg, March 19-22, 2002.

32. Prof. Kumar gave the Keynote Talk at the Stochastic Theory and Control Workshop, Lawrence, KS, Oct 1820, 2001.

33. Prof. Kumar gave the Keynote Talk at SPIE's ITCom 2001 - International Symposium and Exhibit on the Convergence of Information Technology and Communications: Modeling and Design of Wireless Networks. Title of Talk: Three protocols for MAC, Power Control, and Routing in wireless networks Denver, August 23-24, 2001.

34. Prof. Kumar gave the Plenary Talk at the 2001 SIAM Annual Meeting, San Diego, July 1114, 2001.

35. Prof. Kumar served on the Editorial Board, ACM Transactions on Sensor Networks, 2004-2005.

36. Prof. Kumar served as the Editor, Communications in Information and Systems, 1999-.
37. Prof. Kumar served on the Editorial Board of Journal of Discrete Event Dynamic Systems: Theory and Applications, January 1993.
38. Prof. Kumar served as the Associate Editor of Mathematics of Control, Signals, and Systems, 1986-3
39. Prof. Kumar served as the Associate Editor of Mathematical Problems in Engineering: Theory, Methods and Applications, 1995.
40. Prof. Kumar served as the General Chair, The ACM Symposium on Mobile Ad Hoc Networking and Computing, MobiHoc 2005, Chicago, USA.
41. Prof. Kumar served on the Technical Program Committee for the 2006 IEEE International Symposium on Information Theory, Seattle.
42. Prof. Kumar served on the Technical Program Committee of SECON 2004 - The First IEEE International Conference on Sensor and Ad hoc Communications and Networks, Santa Clara, CA, Oct 4-7, 2004.
43. Prof. Kumar served as the Moderator of the Panel on Sensor Networks at IPSN 2004, April 25-27, 2004, Berkeley, CA.
44. Prof. Kumar served on the International Advisory Committee of International Conference on Signal Processing and Communications (SPCOM-2004), Dec. 1114, 2004. Bangalore, India.
45. Prof. Kumar served on the Technical Program Committee for Mobile and Wireless Computing Track of International Conference for Parallel and Distributed Systems (ICPADS), July 79, 2004, Newport Beach.
46. Prof. Kumar served on the Technical Program Committee for SenSys 2004, the Second ACM Conference on Embedded Networked Sensor Systems. November 35, 2004, Baltimore, MD, USA.
47. Prof. Kumar served on the ACM Symposium on Mobile Ad Hoc Networking and Computing, MobiHoc 2004 Technical Program Committee. Tokyo, Japan.
48. Prof. Kumar served on the Technical Program Committee of Workshop on Modeling and Optimization in Mobile and Ad Hoc Networks (WiOpt'04).
49. Prof. Kumar served on the Steering Committee of Information Processing in Sensory Networks (IPSN), 2003-.
50. Prof. Kumar served on the ACM MobiCom 2003 Technical Program Committee. Sep 14-19, 2003. June 1-3, 2003 Annapolis, Maryland.
51. Prof. Kumar served on the IFAC Technical Committee on Stochastic Systems (TC-SS), 2002.

52. Prof. Kumar served on the 2004 IEEE International Symposium on Information Theory Technical Program Committee, Chicago, IL, June 27 to July 2, 2004.
53. Prof. Kumar served on the ACM Symposium on Mobile Ad Hoc Networking and Computing, MobiHoc 2003 Technical Program Committee. June 1-3, 2003 Annapolis, Maryland.
54. Prof. Kumar served on the International Technical Program Committee for the 2003 IEEE International Conference on Communications (ICC), Anchorage, Alaska, May 1115, 2003.
55. Prof. Kumar served on the International Program Committee for the 10th Mediterranean Conference on Control and Automation, Lisbon, Portugal, July 912, 2002.
56. Prof. Kumar served on the International Program Committee, IFAC Workshop on Adaptation and Learning in Control and Signal Processing, Cernobbio-Como, Italy, August 2931, 2001.
57. Prof. Kumar served on the International Program Committee for 10th Mediterranean Conference on Control and Automation, Lisbon, Portugal, July 912, 2002
58. Prof. Kumar served as the Chair of the Organizing Committee for "Workshop on Wireless Networks," Institute for Mathematics and its Applications, Minneapolis, Aug 610, 2001.
59. Prof. Mitter was awarded the Russell-Severance-Springer Chair, Dept. of Electrical Engineering & Computer Science, University of California, Berkeley, CA. (9/2003)
60. Prof. Mitter became a Foreign Member of the Istituto Veneto di Scienze, Lettere ed Arti (2003)
61. Sergio Verdu received was awarded a Doctor Honoris Causa degree by the Polytechnic University of Catalonia, Barcelona, Spain, 2005.
62. Sergio Verdu received the 2002 Leonard G. Abraham Prize Award, IEEE Communications Society.
63. Sergio Verdu was Plenary Lecturer at the 2002 IEEE Int. Symposium on Information Theory, Lausanne, Switzerland, June 2002.
64. Sergio Verdu received the Japan Telecommunications Advancement Foundation Paper Award in 2000.
65. Sergio Verdu received the 2000 Frederick Emmons Terman Award from the American Society of Engineering Education.
66. Sergio Verdu is plenary lecturer of LATIN 2006, (Latin America Theoretical Informatics, 2006), Valdivia, Chile, March 2006.
67. Sergio Verdu gave a Keynote Talk at the New Frontiers of Multiuser Detection Workshop, U. S. Air Force Research Laboratory, Rome, NY, June 20-22, 2005.

68. Sergio Verdu gave a Keynote Talk at SPWC2005: Signal Processing in Wireless Communications Conference. King's College, London, UK, June 13-15, 2005.

69. Sergio Verdu gave an Invited Talk at the The First Kailath Lecture and Colloquium, Stanford University, Stanford, CA, June 10-11, 2005.

70. Sergio Verdu gave a Keynote Talk at 2005 IEEE Workshop on Signal Processing Advances in Wireless Communications, New York, NY, June 5-8, 2005.

71. Sergio Verdu gave a Keynote Talk at 2005 Viterbi Conference: Advancing Technology through Communications Sciences, March 8-9, 2005.

72. Sergio Verdu gave the Distinguished IEEE Communications Society Lecture, IEEE Singapore Chapter of Communications Society, National University of Singapore, Singapore, Dec. 20, 2004.

73. Sergio Verdu gave the Distinguished IEEE Communications Society Lecture, IEEE Hong Kong Chapter of Circuits and Systems and Communications Societies, City University of Hong Kong, Hong Kong SAR, China, Dec. 17, 2004.

74. Sergio Verdu gave the Distinguished IEEE Communications Society Lecture, Tsinghua University, Beijing, China, Dec. 15, 2004.

75. Sergio Verdu gave a Keynote Talk at 2004 PIMRC: 15th IEEE Int. Symp. on Personal, Indoor and Mobile Radio Communications, Barcelona, Spain, Sep. 5-8, 2004.

76. Sergio Verdu gave an Invited Plenary Talk, 2nd International Workshop on Signal Processing for Wireless Communications 2004, London, UK, 2nd - 4th June 2004.

77. Sergio Verdu gave an Invited Keynote Address, 2004 International Zurich Seminar on Communications (IZS), ETH Zurich, Switzerland, Feb. 18-20, 2004.

78. Sergio Verdu gave the joint MSRI-Evans Plenary talk at Mathematics Department, University of California, Berkeley, CA, Feb. 25, 2002.

79. Sergio Verdu serves as Member of the International Advisory Committee, Ninth Intl. Symp. Spread Spectrum Techniques and Applications, Manaus, Brazil, 2006.

80. Sergio Verdu serves as Member of the Program Committee, 2006 IEEE Int. Symp. on Information Theory, Seattle, WA, July 2006.

81. Sergio Verdu serves as Member of the Program Committee and Invited Session Organizer, 2006 IEEE Workshop on Information Theory, Punta del Este, Uruguay, March 2006.

82. Sergio Verdu serves as Member of the Scientific Advisory Board, Telefónica I+D, 2005-present.

83. Sergio Verdu serves as Member of the Technical Advisory Board, Flarion Technologies, 2000-present.

84. Sergio Verdu serves as Member of the Advisory Board, Australian Telecommunications Research Network, 2004-present.

85. Sergio Verdu was named Distinguished Lecturer, IEEE Communications Society, 2004.

86. Sergio Verdu served as Member of the Program Committee, 2005 IEEE Int. Symp. on Information Theory, Adelaide, Australia, September 2005.

87. Sergio Verdu was Co-Chair of the 2004 IEEE Workshop on Information Theory, San Antonio, Oct. 24-29, 2004.

88. Sergio Verdu served as Member of the Technical Program Committee, 2004 International Symposium on Information Theory and Applications (ISITA04), Parma, Italy, Oct. 2004.

89. Sergio Verdu served as Co-Editor, Special Issue of IEEE Journal on Selected Areas on Communications on "Fundamental Performance Limits of Wireless Sensor Networks," vol. 22, no. 6, Aug. 2004.

90. Sergio Verdu served as Member of the Program Committee, 2004 IEEE Int. Symp. on Information Theory, Chicago, IL, June 2004.

91. Sergio Verdu served as Co-organizer, "Information Theory of Wireless Ad Hoc Networks" session, 2004 International Zurich Seminar on Communications (IZS), ETH Zurich, Switzerland, Feb. 18-20, 2004.

92. Sergio Verdu serves as Editor-in-chief, Foundations and Trends in Communications and Information Theory, 2003-present.

93. Sergio Verdu served as Member of the Program Committee, 2003 Communication Technology Alliance Annual Symposium, April 29 - May 1, 2003.

94. Sergio Verdu served as Member of the Program Committee, 2003 IEEE Information Theory Workshop, Paris, France, March 31- Apr. 4, 2003.

95. Sergio Verdu serves as Associate Editor for Book Reviews, IEEE Transactions on Information Theory, 2002-present

96. Sergio Verdu served as Co-Chair, DIMACS Distinguished Princeton-Rutgers Seminar Series in Communications and Information Theory, 2002-2003.

97. Sergio Verdu served as Chair, 2002 MSRI Workshop on Information Theory, Mathematical Sciences Research Institute, Berkeley, Feb. 25 - Mar. 1, 2002.

98. Sergio Verdu served as Member of the Nominations Committee, IEEE Information Theory Society, 2001, 2005.

99. Sergio Verdu served as Chair, 2001 Frederick E. Terman Award Committee, American Society for Engineering Education.

100. Sergio Verdu was elected Distinguished Lecturer, IEEE Communications Society, 2001-2002.
101. Sergio Verdu served as Member of the Program Committee, 2001 IEEE Int. Symp. on Information Theory, Washington, DC, June 2001.
102. Sergio Verdu served as Member of the Organizing Committee, DIMACS Special Focus on Computational Information Theory and Coding, 2000-2002.
103. Sergio Verdu served as Member of the IEEE Hamming Medal Committee, 2000-2004.
104. Sergio Verdu served as Co-Chair, 2000 IEEE Int. Symp. on Information Theory. Sorrento, Italy, June 2000.
105. Sergio Verdu serves as Editor of Communications in Information and Systems, 2000-present.
106. Sergio Verdu served as Organizer, Session on Turbo Multiuser Detection, IEEE Sixth International Symp. on Spread Spectrum Techniques and Applications, Parsippany, NJ Sep. 6-8, 2000.
107. Sergio Verdu served as Member of the Technical Program Committee and International Advisory Committee, IEEE Sixth International Symp. on Spread Spectrum Techniques and Applications, Parsippany, NJ Sep. 6-8, 2000.
108. Prof. Willsky recently received an honorary doctorate from the University of Rennes in France as part of the 25th anniversary of IRISA — a joint INRIA, CNRS Laboratory, 2005.
109. Prof. Willsky was recently named the recipient of the 2004 IEEE Donald G. Fink Prize Paper Award for his paper "Multiresolution Markov Models for Signal and Image Processing."
110. Prof. Willsky's group was invited to contribute a paper describing our work on distributed data association in sensor networks to Mathematical and Computer Modeling, Special Issue on Optimization and Control for Military Applications.
111. Prof. Willsky has recently served on the Air Force Scientific Advisory Board.
112. Prof. Willsky has been chosen by Washington University (St. Louis) as the 2006 John Zaborszky Lecturer and in February 2006 he will deliver a series of lectures on Graphical Models and Distributed Fusion in Sensor Networks.
113. Prof. Willsky has been invited as a Distinguished Speaker by the University of Michigan and will be lecturing on Distributed Fusion in Sensor Networks in February 2006.
114. Prof. Willsky has been invited to speak in Stanford University's Broad Area Colloquium, and he will lecture on Distributed fusion in Sensor Networks in May 2006.

1.3.2 Interactions and Transitions

We have also been extremely active in pursuing interactions with others in academia, industry, and DoD. Many of these interactions, including some of the presentations listed in the preceding subsection, are documented on the website, although others have been more pervasive and continuing are not called out as “highlights” or “events”.

In this subsection we highlight some of these interactions, dividing them into those involving other academic activities and those involving industry and DoD.

Academic Interactions

(1) One of the most substantive interaction has been with the parallel MURI on Decision-Making Under Uncertainty led by Profs. Michael Jordan of Berkeley and Daphne Koller of Stanford, which also involves interactions with the SensIT activities at Berkeley. This interaction has included numerous short and longer term reciprocal visits. Visits from Berkeley to MIT include those by Dr. Sekhar Tatikonda (who was a post-doctoral fellow at Berkeley after finishing his Ph.D. under Prof. Mitter’s supervision at MIT and supported under this MURI), Prof. Michael Jordan, Prof. Laurent El-Ghaoui, Prof. Kannan Ramchandran, and Prof. Martin Wainwright (formerly a Ph.D. student of Prof. Willsky’s supported under this MURI, and subsequently a post-doctoral fellow and now faculty member at UC Berkeley). Visits from MIT to Berkeley include several by Prof. Willsky, an extended visit by Prof. Verdu and by Prof. Mitter, who held the Berkeley Russell-Severance-Springer Chair at Berkeley during his visit.

(2) Interaction with the MURI on Battlefield Visualization, primarily through our group at MIT and Prof. Pramod Varshney of Syracuse University.

(3) The continuation of a long-standing interaction and collaboration with Prof. Randy Moses of Ohio State University, who has had several extended visits to MIT and with whom we have collaborated in several areas. The most significant of these is in the area of sensor location estimation, an area in which Prof. Moses has been working with ARL (in particular with Dr. N. Srour) under the Sensors Collborative Technoligy Alliance. This collaboration has led to new distributed algorithms, developed by Dr. Alexander Ihler (Prof. Willsky and Dr. Fisher’s student), which have been recognized with a Best Paper Award as listed previously.

(4) All of the faculty members of our research team continue to play active leadership roles in the broader research community, including editorial positions on numerous journals, service on IEEE committees, and participation in program committees of major national and international meetings.

Industrial and DoD Interactions and Transitions

The following represent the major interactions and transitions in which we have been involved:

(1) Long-standing interactions with Dr. Feng Zhao (formerly at PARC and now at Microsoft Research), who was funded initially through DARPA's SensIT program, and Dr. Maurice Chu, who completed his Ph.D. at MIT supported under this program and then joined PARC where he leads research on sensor networks for target tracking and other applications.

(2) Continuing transitions and interactions with several programs led by BAE Systems Advanced Information Technologies (BAE-AIT, formerly, ALPHATECH, Inc.). These include:

    a. Transition of our network-constrained fusion algorithms to efforts in support of acoustic/seismic sensor fusion for multitarget tracking in the Army's Raptor program.

    b. Transition of our distributed fusion algorithms as part of efforts under DARPA's Dynamic Tactical Targeting program.

    c. Transition of Dr. Fisher's information-theoretic methods for heterogeneous sensor fusion to programs in feature-aided tracking, DARPA's program in Integrated Sensing and Processing (on which both Dr. Fisher and Prof. Willsky are consultants), and to several programs involving multi-sensor information-theoretic fusion including DARPA's Combat Zones that See program.

    d. Transition of our very recently developed methods for scalable, distributed algorithms for multi-target tracking to several programs including DARPA's NetTrack program.

    e. Transition of our highly scalable inference algorithm to so-called "link discovery" programs at Alphatech (for DARPA, NIMA, NSA, and other agencies). These are very large-scale inference problems involving identifying relationships among very large sets of sensed signals and events.

    f. Transition of our computationally efficient fusion algorithms for battlefield environment estimation (e.g., terrain, road networks, trafficability, weather, etc.)

(3) Continuing interactions with Lincoln Laboratory, including:

    a. A continuing series of seminars, both at MIT by Lincoln researchers and by Prof. Willsky, Dr. Fisher, and their students at Lincoln Laboratory.

    b. Transition of our methods for scalable networked inference to a variety of programs at Lincoln including one on bio-chem sensor networks.

    c. Summer positions for Ms Emily Fox, Prof. Willsky and Dr. Fisher's student.

    d. Transition of our research on information-theoretic sensor resource management.

    e. Regular participation in Lincoln's Adaptive Array and Signal Processing Symposium.

(4) Interactions with ARL and ARL's CTA programs, including:

a. Interactions with the Senior CTA. One significant component of this interaction is our collaboration with Prof. Randy Moses of Ohio State. As mentioned previously, this includes combining our complementary work on sensor location estimation and on algorithms that are robust to sensor location errors as well as using our methods for network-constrained estimation as the basis for distributed versions of Prof. Moses' sensor location estimation algorithms.

b. An extended visit by Alexander Ihler to ARL to work with Dr. Brian Sadler and Mr. Tien Pham. This visit inspired much of Dr. Ihler's subsequent Ph.D. research, for which he has received several Best Paper awards.

c. Collaborative research involving Dr. Brian Sadler of ARL and Dr. Mujdat Cetin of MIT. This work, on sparse channel identification, was inspired directly by Dr. Cetin and his student Dmitry Malioutov's work on the use of so-called "sparsity priors" for new, robust methods for super-resolved source localization.

d. Sergio Verdu is a participating investigator in the CTA-ARL Communications and Networking Consortium led by Telcordia.

(5) ARO activities, including:

a. Prof. Kumar's participation as a panel member in the Triennial Research Strategy Planning Workshop for ARO's Computing and Information Sciences Division, Charleston, SC.

b. Prof. Kumar's role as a member of the Board of Visitors for the Program Review of 6.1 ARL-ARO Mathematics Division, Research Triangle Park, NC, May 2001.

c. Dr. Wainwright's invited talk at the 2002 Army Statistics Meeting (in a session organized by Dr. Wendy Martinez of ONR).

d. The development at ARO of an SBIR topic inspired directly by the research of Dr. John Tsitsiklis of MIT.

(6) AFIT

Major Scott R. Graham, Air Force, Air Force Institute of Technology, obtained his Ph.D. under the guidance of Prof. P.R. Kumar at the Univ. of Illinois. Title of Ph.D. Thesis: "Issues in the Convergence of Control with Communication and Computation," 2004.

Dr. Graham is setting up a laboratory at AFIT based on Prof. P.R. Kumar's Convergence Laboratory at the Univ. of Illinois.

2 Research Highlights

In this section we provide a summary of highlights of our research activities. For obvious reasons our descriptions will be very brief and also represent only a partial look at our research accomplishments. We refer the reader to our web site, our publications, and to previous interim reports and annual briefings for a much more complete look at our research.

(1) Motivated in large part by our research on message-passing algorithms and in particular by our work on sensor localization, we have developed a considerable generalization of particle filtering applicable to problems of inference on graphs with cycles. This new class of *Nonparametric Belief Propagation* (NBP) algorithms has not only been of great value in our research program but it also has already been widely used by others in a wide variety of applications. A software package for NBP is available on the web.

(2) One of the most significant applications of NBP was to the problem of distributed processing for localization of all of the sensors in a sensor network. The resulting algorithm is capable of dealing with the multimodal uncertainty that characterizes this problem and with outliers, resulting in a very powerful algorithm. A paper on this work received a best paper award.

(3) Motivated by the need for limiting communication in power-constrained sensor networks, we have developed a new method of error analysis in belief propagation in order to assess the effect on overall fusion performance of quantization, censoring, and approximation of distributed inference likelihood function messages from one sensor to another. Using a new measure of error, we have developed this tool which also provided the basis for the tightest known conditions for convergence of distributed belief propagation algorithms. A paper on this work received a best paper award.

(4) Similar motivation provided the basis for our investigation of effective methods for transmitting particle-based messages as occur in NBP or in any other message passing algorithm. By exploiting a protocol that is also used for efficiency in NBP — namely a multiresolution organization of particle-based messages and the caching of statistics at each node in this multiresolution tree — we have developed a very flexible and efficient methodology both for the efficient coarse-to-fine transmission of particle-based messages and for the computation of the message error introduced if only coarser resolutions of these messages are transmitted. This provides a direct tie between communication requirements and message error, which, when combined with our work in (3) above, provides the first audit trail from communication constraints to overall fusion performance, as well as a fully adaptive algorithm in which each node can assess the tradeoff between the new information it has to transmit and the communication cost of doing so.

(5) We have developed very powerful theoretical results on message-passing algorithms such as belief propagation. A rich set of these exploit the presence of (many) embedded spanning trees within a loopy network graph. This leads to the framework of *tree-reparameterization*, which we have exploited in numerous ways, including: (a) using convex analysis to prove the existence of fixed points to belief propagation (BP) algorithms and to provide bounds on the errors in BP algorithms — i.e., on the difference between the fusion results of suboptimal, but scalable BP algorithms and the truly optimal answers (which cannot be computed in general in a scalable manner); (b) the development of *tree-reweighting* algorithms that again exploit convexity both to allow efficient computation of the bounds just mentioned and also to provide truly optimal, distributed solutions to the problem of finding the *maximum a posteriori* estimate (i.e., the global configuration over all nodes in the network that has maximum

posterior probability). These results have led to two best paper and one best thesis award and have also provided the basis for other areas of our research (and in particular our work on distributed multi-target data association and tracking).

(6) For the case of Gaussian fusion in sensor networks, we have provided a new and very powerful interpretation of BP algorithms. In particular, we have provided a so-called *walk-sum* interpretation of the computations for estimates and error covariances in BP — an approach that involves careful examination of the propagation and fusion of information through multiple stages of message passing and fusion processing. This analysis provides the basis for the best known sufficient (and almost necessary) conditions for BP convergence for such problems plus a clear picture of the sources of suboptimality in the BP computations of error covariances.

(7) We have developed a rich array of new, general purpose network fusion algorithms each of which satisfies two critical requirements: (a) scalability to very large networks — which generally means that the computational load per sensor is independent of network size; and (b) true optimality or at worst tight control over nearness to optimality. One of these approaches is the class of *Embedded Trees* (ET) algorithms for Gaussian models. These iterative algorithms involve computations on embedded tractable subnetworks (e.g., trees) followed by injection of corrections due to the graph edges that were "cut" in the preceding stage (i.e., the edges not included in the embedded tractable structure). ET algorithms have been demonstrated to have very fast convergence and also yield the true, optimal error covariances for rich classes of models.

(8) Another very powerful set of network fusion algorithms falls under the heading of what refer to as *Recursive Cavity Modeling* (RCM). The basic concept of RCM algorithms is that of fusing information radially outward from sets of "seed" nodes, producing models around the boundaries of radially increasing *cavities* centered on each of these seeds; fusing the cavities as their boundaries meet; and then completing the fusion process by processing information radially inward toward the seed nodes. If no approximations are made, this approach yields truly optimal solutions; however, scalability requires approximations. Specifically, at each stage of propagation of a boundary outward or inward, the exact statistical model corresponds to a very dense (often completely connected) graph. The approximation that must be made is to *thin* this model so that tractable inference can continue and to do so in a manner that is optimal in the sense of minimizing the approximation error in the thinned model. Using deep results in information geometry and maximum entropy modeling, we have developed a principled method for doing this and for doing it in a manner that allows us to control the tradeoff of the level of thinning performed and the informational fidelity of the thinned model. The result is a powerful methodology that allows very flexible processing and scalable, near-optimal performance on very large networks.

(9) One of the principle application area of our work on network-constrained fusion has been in algorithms for scalable, communication-sensitive distributed data association and multi-target tracking in sensor networks. The first contribution of our research in this area was the development of an automatic method for mapping a data association and tracking problem to a graphical model — a step that identifies the informational

relationships among sensors and targets and also makes clear how message-passing should be accomplished (one aspect of this is that the resulting graphical model also identifies a critical problem in sensor networks, namely that of deciding which sensor is responsible for what part of the overall tracking/estimation problem and also for managing *handoff* from one sensor to another as dynamic scenarios evolve. The second contribution of our work was the application of advanced inference algorithms for these graphical models — not only BP but also the tree-reweighted algorithms that yield truly optimal solutions — and for the introduction of a very flexible *message-censoring protocol* in which sensors decide on each iteration if they have sufficient new information to transmit or if their next message should be "censored" (i.e., not transmitted). This leads to fully adaptive algorithms, and experiments on problems of some size (more than 40 targets) provide a picture of clear threshold effects in the tradeoff between censoring threshold and fusion performance — this in turn provides a powerful method for setting these thresholds. The last part of our work has involved the incorporation of NBP algorithms for dynamic tracking and data association. In so doing we have developed a graphical model framework for multi-target tracking that offers the potential of dramatic computational gains over all existing algorithms for this problem — and thus is of considerable value for applications well beyond sensor networks. The key here is the exploitation of NBP's efficient *sampling* of the combinatorially explosive set of possible dynamic data association hypotheses rather than their explicit enumeration and pruning. A paper based on this portion of our work received another best paper award.

(10) We have developed a powerful new variational approach to sparse source localization from passive sensor arrays. We have demonstrated that this approach has superior super-resolution capacity when compared to the most powerful previously developed methods. Moreover the method has far greater robustness to the number of snapshots used, to signal-to-noise ration, and to correlation in the sources being separated (a serious problem in multipath environments). Moreover the technique can deal readily with wideband sources and also allows simultaneous source localization and correction for errors in our knowledge of the locations of the sensors in the array. Our analysis provides conditions under which a convex optimization problem (corresponding to 1-norm, i.e., absolute error) yields the solution to the non-convex problem corresponding to the p-norm with $p < 1$ (and in particular to the true sparseness norm corresponding to $p = 0$). More generally we have developed powerful optimization problems to solve these non-convex problems. These results have been shown to have excellent performance on ARL-provided data sets and also led to collaboration with Dr. Brian Sadler of ARL on another application exploiting sparseness formulations.

(11) We have developed information-theoretic, nonparametric methods for the computation of likelihoods for the associations of signals from multiple sensors. This work was motivated by problems in which dispersive effects (e.g., in the propagation of acoustic signals) are sufficiently severe that coherent array processing methods fail. This approach corresponds to hypothesis testing over factorizations of the joint distributions of mutiple signals (i.e., are particular signals dependent or independent) when we know little or nothing about the forms of the specific details of those factors. This method

has also been successfully applied to the problem of determining if several targets under track are moving independently or in coordination.

(12) We have also developed information-theoretic methods for sensor resource management using dynamic optimization formulations and approximate dynamic programming solution methods that take advantage of the particular structure of such problems for sensor networks. The optimization criteria used in this work combine information-theoretic measures of performance (e.g., entropy of the distribution for the location of a target and mutual information between a target and a potential sensor measurement that can be taken) with terms reflecting the cost of various resource consumption activities which include the tasking of particular sensors to expend power to take and transmit measurements to the node responsible for fusion *and* the communication cost of handing off that fusion responsibility from node to node.

(13) We have also developed a framework for team-optimization in sensor networks. This deals with the recognized problem that sensor networks need to *organize* themselves in order to decide what bits of information each sensor must send to other sensors in order for the overall system to optimize a combined, overall objective. We have demonstrated that the solution to such problems involves message-passing itself — i.e., each node needs to receive messages that (i) allow it to optimize the value of the bits it will send to other nodes; and (ii) provide statistical information so that the node knows how to fuse bits it receives from other nodes in an optimal manner. In essence these optimization problems are aimed at developing a *fusion protocol* for how the sensors should work together. This also makes clear that there is a communication overhead in ad hoc sensor networks that is more significant than in standard ad hoc wireless networks, as in this case, the nodes are working in concert toward a shared (but distributed) objective, requiring another level of coordination beyond that of organizing network connectivity and routing.

(14) We have developed a new algorithm based on Burrows Wheeler block sorting transform to estimate entropy and divergence, which assumes very little knowledge of the sources. We have proved convergence of our algorithm and experiments show that the algorithm converges fast and is computationally efficient. We also study the estimation algorithm based on context tree weighting method and find that with the idea of freezing model, context tree weighting method is very useful in estimating divergence. We apply our algorithm of divergence and mutual information estimation on the MURI data collected by acoustic sensor arrays, and find the preliminary results quite interesting.

(15) We have been investigating various aspects of the theoretical limits on throughput achievable in communication networks. While the goal is to understand ad-hoc configurations, such as applicable to the sensor-web case, simpler models are studied. This facilitates analysis and intuitive understanding. Among our scientific accomplishments are: (i) a derivation of the transport capacity achievable in a broadcast channel scenario and the resource distribution (”power control”) strategies which achieve the best results; (ii) a proof of capacity for a multi-relay degraded Gaussian channel which extends earlier work of Cover and El Gamal and compliments some of the recent work by Xie and Kumar; (iii) a result which shows that random or randomized wired links

in a wireless network can potentially provide significant efficiency improvements over a cellular-type infrastructure.

(16) We have developed optimal resource allocation and scheduling methods in wireless communications, in settings where energy consumption is important and/or other communication resources are limited (as is typically the case in sensor networks). In particular, we provide tractable dynamic programming algorithms that lead to policies under which a transmitter can decide at what times to transmit, depending on the state of the channel, the energy available in the transmitter's battery, and the deadline.

(17) We have developed a new class of network formation models aimed at modeling situations where central coordination is impractical, so each node/sensor will establish connectivity after a "local negotiation," carried out on the basis of perceived self-interest. Our work has resulted in a characterization of the networks that might emerge.

(18) We have studied the dynamics of a set of agents, or sensors, that wish to reach consensus on a certain value (e.g., a common estimate of a parameter being estimated) by exchanging and averaging their current values. We have established broad conditions for convergence (including for the case of complete asynchronism in the information exchange process), as well as convergence rate results. In addition, we have developed variants of the method that can offer improved convergence guarantees.

(19) In joint work with Nigel Newton (University of Essex, UK), we have given a Variational Interpretation of Bayesian Inference in terms of a minimization of Free Energy, and shown how the path estimation problem for a diffusion process $(X_t)_{t\geq 0}$ given noisy observations $(Y_t)_{t\geq 0}$, leads to a structure for the estimator as a backward likelihood Filter composed with an appropriate forward Optimal Markovian Stochastic Controller. The conditional distribution is then the path-space measure of the optimally controlled stochastic system. In subsequent work we have given a statistical mechanical interpretation of the Kalman Filter by studying it in terms of the interaction between the signal, observation and the filter. A new notion of Interactive Entropy production is presented and it is shown how the Kalman Filter is informationally optimal and satisfies a Second Law of Thermodynamics.

(20) We are currently exploring the interaction of information and control along different directions. The first line of investigation is to establish, as a starting point, analogies between problems of information transmission and problems of control, and use these in order to "transport" known results from one area to the other. One particular point of contact between information and control that we have been and are currently studying is the following: It is well-known in information theory that the use of feedback does not increase the capacity of memoryless channels, while for channels with memory, feedback does often increase the channel capacity. The analogy with the control of mechanical systems is clear: The "memory" of a communication channel corresponds to the "inertia" of a mechanical system, and just as with memoryless channels of information theory, mechanical systems without inertia can be controlled without the use of feedback. This points further to a duality between information and control: Controlling a given plant can be interpreted as transmitting a message (desired state

trajectory) through the plant. The plant controller acts here as the message encoder, while the state observer acts as the message decoder. The output of the observer is the received message. We are attempting to substantiate these superficial analogies by establishing mathematical results that allow us to reinterpret information transmission problems as control problems, and vice-versa.

(21) Another line of investigation we are pursuing takes as its starting point the work of Mitter and Sahai on anytime information theory. It has been shown in that work that the use of information transmission in a control application, e.g. communicating the observer output back to the controller via a noisy finite-rate communication channel, forces us to rethink classical notions of information theory, and to forge new tools to address the problems engendered by the interaction of communication and control. The basic result that has been established in that work is that in this new context, it is not enough to merely get the bits across the communication channel, it is also essential to know what these bits will be used for. This is a major departure from classical information theory, and leads to channel characterizations which are application-dependent and go well beyond coarse single-number characterizations such as Shannon capacity and ergodic capacity. The channel characterization (anytime capacity) established by Mitter and Sahai dealt with one specific application, that of feedback stabilization of a linear control system, and this characterization hinges in an essential way on the linearity of the control system. We are currently investigating application-dependent channel characterizations for control systems which are not necessarily linear and for control objectives other than stabilization.

(22) One extension of these ideas is to consider a dense network of systems linked via communication channels. Necessary and sufficient conditions on the communication channels are to be derived for the network to exhibit a desired behavior. Although this problem seems orders of magnitude more complex than that of a single control system with a single communication channel in the feedback loop, we are interested in the limiting behavior of such networks as the number of sub-systems and channels grows unbounded, and we believe the complexity of behavior of such a network can be tamed in the limit as its size becomes infinite. We are attempting to extract partial differential equations that describe the flow of information in such a network. We expect notions such as "capacity density" in a (continuous) network to play a role akin to that of capacity (Shannon, ergodic, anytime,...) of a single communication channel and to provide a key characterization of the behavior of such networks, which can then be classified as homogeneous or inhomogeneous, according to whether they do or do not have constant capacity density. We are especially interested in conservation laws that could be established from these partial differential equations, and we believe such an analysis could benefit the design of communication networks.

(23) The consideration of communication networks has led us to revisit one particular classical channel, the Gaussian broadcast channel. For scalar Gaussian broadcast channels, it has been known for a long time that the Gaussian rate region is not only achievable, but that it is also the capacity region. The proof of this last statement makes crucial use of Shannon's entropy power inequality. For MIMO Gaussian broadcast channels, the achievability of the Gaussian rate region has also been long established, but, until

very recently, all attempts at proving that the Gaussian rate region is also the capacity region for such channels had failed. Very recent work by Shamai and his collaborators has bridged this gap using a very clever idea that allows the entropy power inequality proof of the scalar case to go through. Unfortunately, the results of Shamai and his collaborators are very closely tied to the Gaussianity of the channel considered, and cannot be extended to the case of non-Gaussian broadcast channels. We have studied an alternative to Shamai's proof with the explicit concern that the underlying principle transcend the particular channel characteristics, and in particular, its Gaussianity. The proof we propose, and which is only partly completed, hinges on the basic idea of dimensionality reduction, that which is found in all realms of mathematics, and especially in the Lie theory of differential equations and their solvability by quadrature. The basic idea is as follows: If a MIMO channel with t transmit and receive antennas has a certain capacity, then there exists a sequence of codebooks (with codewords of length n, vectors in nt-dimensional space) with rate approaching capacity and probability of error going to zero. From this codebook, we can, by projection onto an $n(t-1)$-dimensional sub-manifold, extract a codebook for a $(t-1)$-dimensional MIMO channel with a certain limiting rate and with probability of decoding error approaching zero. The key technical passage is to compute estimates of the size of the maximal such projected codebook, and we are currently working on this. For Gaussian MIMO broadcast channels, the projection can be linear and the sub-manifold, a linear subspace. a Gaussian MIMO broadcast channel with t transmit/receive antennas is then reduced to a Gaussian MIMO broadcast channel with $(t-1)$ transmit/receive antennas, but with the same number of users. Reducing step by step the problem to that of the scalar Gaussian broadcast channel allows us to establish the capacity region for the MIMO case using the existing result for the scalar case. As alluded to above, the projection sub-manifold need not be a linear subspace, and the projection need not be linear, and we believe this line of proof can be generalized to non-Gaussian MIMO broadcast channels. This is joint work with Abdol-Reza Mansouri.

(24) We developed a novel approach to detection of bio-releases using sparse sensor configurations. The networks of interest were comprised of bio material sensors (i.e. type and concentration) and a smaller number of wind field sensors (i.e. anemometers). A consequence of sparse configurations is that the wind field is highly uncertain complicating the use of strong physical models. This research focused on using approximate physical models combined with optimal inference procedures. The parameters of interest were detection, time-to-detection, and localization for a fixed false alarm rate. Experiments were designed to analyze the sensitivity of optimal inference methods in which the underlying physical model of dispersion deviated from that assumed by the inference procedure. While it was expected that localization performance would degrade, it was shown that detection probabilities and time-to-detection performance were more robust to model deviation in a limited number of experiments.

(25) Matrix completion problems arise in settings where the data of interest can be arranged in a matrix form as in sensors versus objects detectable by the sensors. Only a small fraction of the entries of the large data matrix are assumed to be known a priori and the goal is to accurately predict the remaining entries. The predictions are collaborative

in nature in the sense that they make tacit use of shared properties across sensors and objects. We have developed new algorithms and theoretical analysis of collaborative prediction based on extending the maximum margin concept from supervised learning to sparse matrix completion problems. The estimation task is formulated as a convex optimization problem via trace norm regularization, and can be solved efficiently in the dual form, a sparse semi-definite program. Our generalization performance analysis, through the use of Rademacher complexity, represents the first generalization analysis of matrix completion methods.

(26) We have developed a new information theoretic framework for solving distributed estimation and inference tasks. We focus in particular on the setting where little is known about the probabilistic interactions between the variables of interest. We complement the absence of quantitative dependencies by translating structural (relational and topological) constrains into information theoretic biases about the values of the variables. In our framework, each object of interest (e.g., sensor) is associated with a set of variables describing them. The relations between objects serve to bias the probability models governing the variables to be similar. A collection of such biases define a regularization approach that responds appropriately to any non-uniformity induced by limited observations. The regularization objective is minimized in an iterative manner through distributed dual projection operations (e- and m-projections). The regularization approach generalizes estimation of structured probability models from incomplete data, reducing to it in the simplest case.

(27) Prof. Kumar and his students Kurt Plarre and Roberto Solis have developed an algorithm for estimating the tracks of moving objects when the only information is the time information as objects cross highly directional sensors. The algorithm determines the sensor directions as well. It has been implemented on Motes.

(28) Prof. Kumar and his student Arvind Giridhar have developed a theory of in-network processing in sensor networks. This theory allows the characterization of the computational rate for some classes of symmetric functions such as the Mean, Max, Mode, etc.

3 PUBLICATIONS

The following is a list of papers, theses, and other publications of research supported in whole or in part under Grant DAAD19-00-0466

(A) Published in Peer-Reviewed Journals

1. A. Agarwal, P. R. Kumar. Capacity bounds for ad-hoc and hybrid wireless networks. ACM SIGCOMM Computer Communication Review: Special Issue on Science of Networking Design, vol. 34, no. 3, July 2004. pp. 71-81.

2. A. Agarwal, P. R. Kumar. Improved Capacity Bounds for Wireless Networks. Wireless Communications and Mobile Computing, vol. 4, May 2004. pp. 251-261.

3. G. Baliga, P. R. Kumar. Middleware Architecture for Federated Control Systems. IEEE Distributed Systems Online, June 2003.

4. P. L. Bartlett, S. Ben David, S. R. Kulkarni. Learning Changing Concepts by Exploiting the Structure of Change. Machine Learning, November 2000. pp. 153-174.

5. L. Bazzi, S.K. Mitter. Encoding Complexity Versus Minumum Distance. IEEE Trans. on Info. Theory, vol. 51 no. 6, June 2005. pp. 2103-2112.

6. V. Borkar, P. R. Kumar. Dynamic Cesaro-Wardrop Equilibration in Networks. IEEE Transactions on Automatic Control, vol. 48, no. 3, March 2003. pp. 382-396 .

7. V.S. Borkar, V.R. Konda, S.K. Mitter. On De Finetti Coherence and Kolmogorov Probability. Stat. Prob. Lett, 66, 2004. pp. 417-421.

8. V.S. Borkar, S.K. Mitter, S.R. Venkatesh. Variations on a Theme by Neyman and Pearson. Sankhya, vol. 66, part II, May 2004. pp. 292-305.

9. H. Cai, S.R. Kulkarni, S. Verdu. Universal Estimation of Entropy Via Block Sorting. IEEE Transactions on Information Theory, vol. 50, no. 7, July 2004. pp. 1551-1561.

10. G. Caire, S. Guemghar, A. Roumy, S. Verdu. Maximizing the Spectral Efficiency of coded CDMA under successive decoding. IEEE Transactions on Information Theory, vol. 50, no. 1, January 2004. pp. 152-164.

11. G. Caire, D. Tuninetti, S. Verdu. Suboptimality of TDMA in the low power regime. IEEE Transactions on Information Theory, vol. 50, no. 4, April 2004. pp. 608-620.

12. G. Caire, S. Shamai and S. Verdu. Noiseless Data Compression with Low-Density Parity-Check Codes. DIMACS Series in Discrete Mathematics and Theoretical Computer Science, 2004. pp. 263-284.

13. G. Caire, D. Tuninetti, and S. Verdu. Variable-rate Coding for Slowly-fading Gaussian Multiple-access Channels. IEEE Transactions on Information Theory, October 2004. pp. 2271-2292.

14. G. Caire, S. Shamai, A. Shokrollahi and S. Verdú. Fountain Codes for Lossless Data Compression. *Algebraic Coding Theory and Information Theory*, A. Ashikhmin, A. Barg, I. Duursma, DIMACS Series in Discrete Mathematics and Theoretical Computer Sciences, vol. 68, pp. 1-20, American Mathematical Society Press, 2005.

15. M. Chu, H. Haussecker, F. Zhao. Scalable Information-Driven Sensor Querying and Routing for ad hoc Heterogeneous Sensor Networks. International Journal of High Performance Computing Applications.

16. A. Corduneanu, T. Jaakkola. Data dependent regularization. (to appear in:) "Semi-supervised learning", O. Chapelle, A. Zien, B. Schlkopf (eds.), 2005.

17. M. Dmitry, M. Cetin, and A.S. Willsky. Sparse Signal Reconstruction Perspective for Source Localization with Sensor Arrays. Transactions on Signal Processing, 2005.

18. M. Effros, K. Visweswariah, S. Kulkarni, S. Verdu. Universal Lossless Source Coding With the Burrows Wheeler Transform. IEEE Transactions on Information Theory, May 2002. pp. 1061-1081.

19. John W. Fisher III, Martin Wainwright, Erik Sudderth, Alan S. Willsky. Statistical and Information-Theoretic Methods For Self-Organization And Fusion Of Multimodal, Networked Sensors. In Review, September 2001.

20. A. Fu, E. Modiano, J. N. Tsitsiklis. Optimal Transmission Scheduling over a Fading Channel with Energy and Deadline Constraints. IEEE Transactions on Wireless Communications, February 2006.

21. A.P. George, W.B. Powell, S.R. Kulkarni. The Statistics of Hierarchical Aggregation for Multiattribute Resource Management. INFORMS Journal on Computing.

22. A. Giridhar, P. R. Kumar. Maximizing the Functional Lifetime of Sensor Networks. Proceedings of The Fourth International Conference on Information Processing in Sensor Networks, IPSN 2005, April 2005.

23. A. Giridhar, P. R. Kumar. Computing and Communicating functions over Sensor Networks. IEEE Journal on Selected Areas in Communication, vol. 23, no. 4, April 2005. pp. 755-764.

24. D. Guo, S. Verdu, L. K. Rasmussen. Asymptotic normality of linear multiuser receiver outputs. (to appear in:) IEEE Transactions on Information Theory.

25. D. Guo, S. Shamai, and S. Verdu. Mutual Information and Minimum Mean-Square Error in Gaussian Channels. IEEE Transactions on Information Theory, April 2005. pp. 1261-1283.

26. D. Guo, S. Verdu. Randomly Spread CDMA: Asymptotics via Statistical Physics. IEEE Transactions on Information Theory, June 2005. pp. 1983-2010.

27. N. Gupta, P. R. Kumar. A performance analysis of the IEEE 802.11 Wireless LAN Medium Access Control. (to appear in:) Communications in Information and Systems, Revised June, 2004.

28. P. Gupta, P. R. Kumar. Towards an Information Theory of Large Networks: An Achievable Rate Region. IEEE Trans. on Information Theory, vol 49, no. 8, August 2003. pp. 1877-1894.

29. M. Gursoy, H. V. Poor and S. Verdú. The Noncoherent Rician Fading Channel – Part II: Spectral Efficiency in the Low-Power Regime. IEEE Trans. Wireless Communications, vol. 4, no. 5, pp. 2207- 2221, Sep 2005.

30. M. Gursoy, H. V. Poor and S. Verdú. On-Off Frequency-Shift-Keying for Wideband Fading Channels. (to appear in:) EURASIP Journal on Wireless Communications and Networking, no. 1, 2006.

31. A. Ihler, J. W. Fisher III, A. S. Willsky. Loopy Belief Propagation: Convergence and Effects of Message Errors. Journal of Machine Learning Research, May 2005.

32. A. Ihler, J. W. Fisher III, R. L. Moses, A. S. Willsky. Nonparametric Belief Propagation for Sensor Network Self-Calibration. IEEE Journal of Selected Areas in Communications, April 2005.

33. A. Ihler, J. W. Fisher III, A. S. Willsky. Nonparametric Hypothesis Tests for Statistical Dependency. Transactions on Signal Processing, August 2004.

34. T. Jaakkola. Tutorial on variational approximation methods. Advanced mean field methods: theory and practice, MIT Press, 14, September 2000.

35. J.K. Johnson, A.S. Willsky. A Recursive Model-Reduction Method for Approximate Inference in Gaussian Markov Random Fields. IEEE Trans. Image Processing, June 2005.

36. A.Jovicic, P. Viswanath, S.R. Kulkarni. Upper Bounds to Transport Capacity of Wireless Networks. IEEE Transactions on Information Theory.

37. V. Kawadia, P. R. Kumar. A Cautionary Perspective on Cross Layer Design. IEEE Wireless Communication Magazine, vol. 12, no. 1, February 2005. pp. 3-11.

38. V. Kawadia, P. R. Kumar. Principles and Protocols for Power Control in Wireless Ad Hoc Networks. IEEE Journal on Selected Areas in Communications, vol. 23, no. 1, January 2005. pp. 76-88.

39. S. R. Kulkarni, G. Lugosi. Finite Time Lower Bounds for the Two-Armed Bandit Problem. IEEE Transactions on Automatic Control, April 2000. pp. 711-714.

40. S.R. Kulkarni, S.E. Posner, S. Sandilya. Data-dependent kn-NN and Kernel Estimators Consistent for Arbitrary Processes. IEEE Transactions on Information Theory, October 2002.

41. S.R. Kulkarni, P. Viswanath. A Deterministic Approach to Throughput Scaling in Wireless Networks. IEEE Transactions on Information Theory, vol. 50, no. 6, June 2004. pp. 1041-1049.

42. L. Li, A. Tulino, S. Verdu. Asymptotic Eigenvalue Moments for Linear Multiuser Detection. Communications in Information and Systems, September 2001. pp. 273-304.

43. L. Li, A. M. Tulino, S. Verdu. Design of Reduced-rank MMSE Multiuser Detectors using Random Matrix Methods. IEEE Transactions on Information Theory, vol. 50, no. 6, June 2004. pp. 986-1008.

44. A. Lozano, A. M. Tulino and S. Verdú. High-SNR Power Offset in Multi-Antenna Communication. IEEE Trans. Information Theory, vol. 51, no. 12, pp. 4134- 4151, Dec. 2005.

45. A. Lozano, A. Tulino and S. Verdú. Multiantenna capacity: Myths and Realities. Chapter 8 in *Space-Time Wireless Systems: from Array Processing to MIMO Communications*, H. Bölcskei, D. Gesbert, C. Papadias, and A.J. van der Veen, Eds., Cambridge University Press, 2006.

46. A. Lozano, A. M. Tulino and S. Verdú. Capacity-Achieving Input Covariance for Single-user Multi-Antenna Channels. (to appear in:) IEEE Trans. Wireless Communications, Feb. 2006.

47. S. Mannor, R. Meir, T. Zhang. Greedy Algorithms for Classification – Consistency, Convergence Rates, and Adaptivity. Journal of Machine Learning Research, vol. 4, October 2003. pp. 713-741.

48. S. Mannor, J. N. Tsitsiklis. The Sample Complexity of Exploration in the Multi-Armed Bandit Problem. Journal of Machine Learning Research, vol. 5, June 2004. pp. 623-648.

49. S.K. Mitter. Duality Between Estimation and Control. Festschrift for A. Bensoussan, December 2000.

50. S.K. Mitter. Control with Limited Information. Eur. Jrn. Control, vol. 7, 2001. pp. 122-131.

51. S.K. Mitter, N. J. Newton. A Variational Approach to Nonlinear Estimation. SIAM Journal on Control, vol. 42, no. 5, 2004. pp. 1813-1833.

52. S.K. Mitter, N.J. Newton. Information and Entropy Flow in the Kalman-Bucy Filter. J. of Stat. Phys., vol. 118, 2005. pp. 145-176.

53. R. Mueller, S. Verdu. Design and Analysis of Low-Complexity Interference Mitigation on Vector Channels. IEEE Journal on Selected Areas on Communications, August 2001. pp. 1429-1441.

54. D.P. Palomar and S. Verdú. Gradient of Mutual Information in Linear Vector Gaussian Channels. IEEE Trans. on Information Theory, Vol. 52, no. 1, pp. 141-154, Jan. 2006.

55. K. Plarre, P. R. Kumar. Extended Message Passing Algorithm for Inference in Loopy Gaussian Graphical Models. Ad Hoc Networks, vol. 2, 2004. pp. 153-169.

56. V. V. Prelov, S. Verdu. Second-order Asymptotics of Mutual Information. IEEE Transactions on Information Theory, August 2004. pp. 1567-1580.

57. A. Reznik, S.R. Kulkarni, S. Verdu. Capacity and Optimal Resource Allocation in the Degraded Gaussian Relay Channel with Multiple Relays. IEEE Transactions on Information Theory.

58. A. Reznik, S.R. Kulkarni, S. Verdu. A Small World Approach to Heterogeneous Networks. Communications in Information and Systems, September 2004. pp. 325-348.

59. A. Reznik, S.R. Kulkarni, S. Verdu. Degraded Gaussian multi-relay channel: capacity and optimal power allocation. IEEE Transactions on Information Theory, December 2004. pp. 3037-3046.

60. S. Rickard, R. Balan, H. V. Poor and Verdú. Canonical Time-Frequency, time-scale and frequency-scale representations of time-varying channels. Communications in Information and Systems, vol. 5, no. 1, pp. 197-226, 2005.

61. S. Sandilya, S.R. Kulkarni. Principal Curves with Bounded Turn. IEEE Transactions on Information Theory, October 2002.

62. S. (Shitz) Shamai, S. Verdu. Decoding only the Strongest CDMA Users. Codes, Graphs, and Systems. pp. 217-228.

63. S. (Shitz) Shamai, S. Verdu. Decoding only the Strongest CDMA Users. Forney Festshrift, 2001.

64. S. Shamai, S. Verdu. The Impact of Frequency-flat Fading on the Spectral Efficiency of CDMA. IEEE Transactions on Information Theory, May 2001. pp. 1302-1327.

65. E. Sudderth, M. J. Wainwright, A. S. Willsky. Embedded Trees: Estimation of Gaussian Processes on Graphs with Cycles. IEEE Transactions on Signal Processing, November 2004. pp. 3136-3150.

66. R. Sundaresan and S. Verdú. Capacity of Queues via Point-Process Channels," (to appear in:) IEEE Trans. Information Theory, 2006.

67. Y.-P. Tan, D. D. Saur, S. R. Kulkarni, P. J. Ramadge. Rapid Estimation of Camera Motion from Compressed Video With Application to Video Annotation. IEEE Transactions on Circuits and Systems for Video Technology, February 2000. pp. 133-146.

68. S. Tatikonda, S.K. Mitter. Control over Noisy Channels. IEEE Trans. on Auto. Control, vol. 9 no. 7, July 2004. pp. 1196-1201.

69. S. Tatikonda, S.K. Mitter. Control under Communication Constraints. IEEE Trans. on Auto. Control, vol. 9 no. 7, July 2004. pp. 1056-1068.

70. S. Tatikonda, A. Sahai, S.K. Mitter. Stochastic Linear Control over a Communication Channel. IEEE Trans. on Auto. Control, Special Issue on Networked Control Systems, vol. 49 no. 9, September 2004. pp. 1549-1561.

71. A. Tulino, S. Verdu. Asymptotic Analysis of Improved Linear Receivers for BPSK-CDMA subject to Fading. IEEE Journal on Selected Areas on Communications, August 2001. pp. 1544-1555.

72. A. Tulino, S. Verdu. Random Matrices and Wireless Communications. Foundations and Trends in Communications and Information Theory, vol. 1, no. 1, June 2004.

73. A. Tulino, A. Lozano, S. Verdu. Impact of antenna correlation on the capacity of multiantenna channels. IEEE Trans. Info. Theory, July 2005. pp. 2491-2509.

74. A. Tulino, L. Li and S. Verdu. Spectral Efficiency of Multicarrier CDMA. IEEE Transactions on Information Theory, February 2005. pp. 479-505.

75. S. Verdu. Recent Results on the Capacity of Wideband Channels in the Low Power Regime. IEEE Personal Communications Magazine, August 2002.

76. S. Verdu. Spectral Efficiency in the Wideband Regime (Invited Paper). IEEE Trans. Information Theory, Special Issue on Shannon Theory: Perspective, Trends and Applications, June 2002. pp. 1319-1343.

77. M. Vidyasagar, S. R. Kulkarni. Some Contributions to Fixed-Distribution Learning Theory. IEEE Transactions on Automatic Control, February 2000. pp. 217-234.

78. K. Visweswariah, S. R. Kulkarni, S. Verdu. Asymptotically Optimal Variable-to-Fixed Length Codes for Markov Sources. Journal of Combinatorics, Information, and System Sciences, 2000.

79. K. Visweswariah, S. R. Kulkarni, S. Verdu. Separation of random number generation and resolvability. IEEE Transactions on Information Theory, September 2000. pp. 2237-2241.

80. K. Visweswariah, S. R. Kulkarni, S. Verdu. Universal Coding of Nonstationary Sources. IEEE Transactions on Information Theory, July 2000. pp. 1633-1637.

81. K. Visweswariah, M. Effros, S. Kulkarni, S. Verdu. Data compression based on the Burrows-Wheeler transform: Analysis and optimality. IEEE Transactions on Information Theory, 2001. pp. 1461-1472.

82. K. Visweswariah, S. Kulkarni, S. Verdu. Universal Variable-to-Fixed Length Source Codes. IEEE Transactions on Information Theory, May 2001. pp. 1461-1472.

83. M.J. Wainwright, T.S. Jaakkola, A.S. Willsky. A new class of upper bounds on the log partition function. (to appear in:) IEEE Trans. on Info. Theory, 2005.

84. M.J. Wainwright, E. P. Simoncelli, A. S. Willsky. Random cascades on wavelet trees and their use in analyzing and modeling natural images. Applied Computational and Harmonic Analysis (Special issue on wavelet applications), April 2001.

85. M.J. Wainwright, T.S. Jaakkola, A.S. Willsky. Tree consistency and bounds on the performance of the max-product algorithm and its generalizations. Statistics and Computing, vol. 14, no. 2, 2004. pp. 143-166.

86. C.-C. Wang, S.R. Kulkarni, H.V. Poor. Density Evolution for Asymmetric Memoryless Channels. IEEE Trans. on Info. Theory.

87. C.-C. Wang, S.R. Kulkarni, H.V. Poor. Arbitrary Side Observations in Bandit Problems. Annals of Applied Probability, 2003.

88. C.-C. Wang, S.R. Kulkarni, H.V. Poor. Arbitrary Side Observations in Bandit Problems. Advances in Applied Mathematics, May 2005. pp. 903-938.

89. C.-C. Wang, S.R. Kulkarni, H.V. Poor. Bandit Problems With Side Observations. IEEE Trans. on Auto. Control, May 2005. pp. 338-355.

90. Q. Wang, S. Kulkarni and S. Verdu. Divergence estimation of continuous distributions based on data-dependent partitions. IEEE Trans. on Info. Theory, September 2005.

91. Q. Wang, S. Kulkarni and S. Verdú. Divergence Estimation of Continuous Distributions based on Data-Dependent Partitions. IEEE Trans. Information Theory, vol. 51, no. 9, pp. 364-374, Sep 2005.

92. T. Weissman, E. Ordentlich, G. Seroussi, S. Verdu and M. Weinberger. Universal Discrete Denoising: Known Channel. IEEE Trans. on Info. Theory, January 2005. pp. 5-28.

93. Alan S. Willsky. Multiresolution Markov Models for Signal and Image Processing. Proceedings of the IEEE, vol. 90, no. 8, August 2002. pp. 1396-1458.

94. L.-L. Xie, P. R. Kumar. On the path-loss attenuation regime for positive cost and linear scaling of transport capacity in wireless networks. (to appear in:) IEEE Trans. on Info. Theory.

95. L.-L. Xie, P. R. Kumar. A Network Information Theory for Wireless Communication: Scaling Laws and Optimal Operation. IEEE Transactions on Information Theory, vol. 50, no. 5, May 2004. pp. 748-767.

96. L.-L. Xie, P. R. Kumar. An achievable rate for the multiple-level relay channel. IEEE Trans. on Info. Theory, vol. 51, no. 4, April 2005. pp. 1348-1358.

97. F. Xue, L-L. Xie, P. R. Kumar. Wireless Networks over Fading Channels. (to appear in:) IEEE Trans. on Info. Theory.

98. F. Xue, P. R. Kumar. On the Theta-coverage and connectivity of large random networks. (to appear in:) IEEE Trans. on Info. Theory.

99. F. Xue, P. R. Kumar. The number of neighbors needed for connectivity of wireless networks. Wireless Networks, vol. 10, no. 2, March 2004. pp. 169-181.

100. F. Xue, L-L. Xie, P. R. Kumar. The Transport Capacity of Wireless Networks over Fading Channels. IEEE Trans. on Info. Theory, vol. 51, no. 3, March 2005. pp. 834-847.

101. Zaidel, S. Shamai (Shitz), S. Verdu. Multi-cell uplink spectral efficiency of Coded DS-CDMA with Random Signatures. IEEE Journal on Selected Areas on Communications, August 2001. pp. 1556-1569.

(B) Published in Non-Peer-Reviewed Journal or Conference Proceedings

1. G. Alfano, A. Lozano, A. Tulino and S. Verdu. Mutual Information and Eigenvalue Distribution of MIMO Ricean Channels. 2004 International Symposium on Information Theory and its Applications, October 2004.

2. G. Alfano, A. Lozano, A. Tulino and S. Verdú. Random Matrix Transforms and Applications Via Nonasymptotic Eigenanalysis. 2006 International Zurich Seminar, (invited paper), Feb. 22-24, 2006.

3. R. Balan, H. V. Poor, S. Rickard, S. Verdu. Time-frequency and time-scale canonical representations of doubly spread channels. EUSIPCO, September 2004.

4. G. Baliga and P. R. Kumar, "A Middleware for Control over Networks," Proceedings of the 44th IEEE Conference on Decision and Control, (Invited paper), Seville, Spain, December 2005.

5. G. Baliga, S. Graham, L. Sha, P. R. Kumar. Etherware: Domainware for Wireless Control Networks. Proceedings of the Seventh IEEE International Symposium on Object-Oriented Real-Time Distributed Computing, Vienna, May 2004. pp. 155-162.

6. Louay Bazzi. Minimum Distance of Error Correcting Codes versus Encoding Complexity, Symmetry, and Pseudorandomness. MIT PhD thesis, Laboratory for Information and Decision Systems, September 2003.

7. V. Blondel, J. M. Hendrickx, A. Olshevsky, J. N. Tsitsiklis. Convergence in Multiagent Coordination, Consensus, and Flocking. 2005 IEEE Conference on Decision and Control, December 2005.

8. H. Cai, S. R. Kulkarni, S. Verdu. Universal Estimation of Entropy and Divergence Via Block Sorting. ISIT 2002, January 2002.

9. H. Cai, S. R. Kulkarni, S. Verdu. A Universal Lossless Compressor with Side Information Based on Context Tree Weighting. Proc. IEEE Int. Symp. Inform. Theory, September 2005.

10. G. Caire, D. Tuninetti, S. Verdu. Is TDMA Optimal in the Low Power Regime? Proceedings of International Symposium on Information Theory, 2002.

11. G. Caire, S. Shamai, S. Verdu. Constructive Approaches to Fixed-Length Data Compression. IEEE Int. Symp. Information Theory, July 2003.

12. G. Caire, S. Shamai, S. Verdu. Almost-Noiseless Joint Source-Channel Coding-Decoding of Sources with Memory. 5th International ITG Conference on Source and Channel Coding, January 2004.

13. G. Caire, S. Shamai, A. Shokrollahi S. Verdu. Fountain Codes for Lossless Compression of Binary Sources. IEEE Workshop on Information Theory, San Antonio, October 2004.

14. G. Caire, S. Shamai, and S. Verdu. Practical Schemes for Interactive Data Exchange. 2004 International Symposium on Information Theory and its Applications, October 2004.

15. M. Cetin, D. M. Malioutov, A. S. Willsky. A Variational Technique for Source Localization based on a Sparse Signal Reconstruction Perspective. IEEE International Conference on Acoustics Speech and Signal Processing (ICASSP), vol. 3, May 2002. pp. 2965-2968.

16. L. Chen, M. J. Wainwright, M. Cetin, A.S. Willsky. Data Association based on Optimization in Graphical Models with Application to Sensor Networks. (to appear in:) Mathematical and Computer Modelling, Special Issue on Optimization and Control for Military Applications, (Invited paper).

17. L. Chen, M. J. Wainwright, M. Cetin, A. S. Willsky. Multitarget-Multisensor Data Association Using the Tree-ReweightedMax-Product Algorithm. SPIE Aerosense, April 2003.

18. L. Chen, M. Cetin, A. S. Willsky. Distributed Data Association for Multi-Target Tracking in Sensor Networks. Information Fusion 2005, July 2005.

19. L. Chen, M. Cetin, A. S. Willsky. Graphical Model-based Algorithms for Data Association in Distributed Sensing (Presentation). The Thirteenth Annual Workshop on Adaptive Sensor Array Processing, Lincoln Lab, MIT, June 2005.

20. M. Chu, S. Mitter , F. Zhao. An Information Architecture for Distributed Inference in Ad Hoc Sensor Networks. 41st Annual Allerton Conference on Communication, Control, and Computing, November 2003.

21. M. Chu, S. Mitter , F. Zhao. Distributed Multiple Target Tracking and Data Association in Ad Hoc Sensor Networks. 6th Internatinal Conference on Information Fusion, July 2003.

22. Maurice Chu. A Hierarchical Framework for Constructing Computationally Efficient Algorithms for Distributed Inference Problems. MIT PhD thesis, Laboratory for Information and Decision Systems, February 2003.

23. A. Corduneanu, T. Jaakkola. Stable mixing of complete and incomplete information. MIT AI Memo AIM-2001-030, November 2001.

24. A. Corduneanu, T. Jaakkola. Continuation Methods for Mixing Heterogeneous Sources. Proceedings of the Eighteenth Annual Conference on Uncertainty in Artificial Intelligence, May 2002.

25. A. Corduneanu, T. Jaakkola. On Information Regularization. UAI 03, (best paper award), March 2003.

26. A. Corduneanu, T. Jaakkola. Distributed Information Regularization on Graphs. Advances in Neural Information Processing Systems, 17, June 2004.

27. J.W. Fisher III, Alexander T. Ihler, Paul Viola. Learning Informative Statistics: A Nonparametric Approach. Advances in Neural Information Processing Systems, 12, December 1999. pp. 900-906.

28. J.W. Fisher III, Trevor Darrell, William Freeman, Paul Viola. Learning Joint Statistical Models for Audio-Visual Fusion and Segregation. Advances in Neural Information Processing Systems, 13, December 2000.

29. J.W. Fisher III, Trevor Darrell. Signal Level Fusion for Multimodal Perceptual User Interface. Workshop on Perceptive User Interfaces, October 2001.

30. J.W. Fisher III, Trevor Darrell. Informative subspaces for audio-visual processing: high-level function from low-level fusion. ICASSP, May 2002.

31. J.W. Fisher III, Trevor Darrell. Probabilistic models and informative subspaces for audiovisual correspondence. European Conference on Computer Vision, volume III, June 2002. Page 592.

32. E. Fox. Detection and Localization of Aerosol Releases from Sparse Sensor Measurements. MIT MEng thesis, Laboratory for Information and Decision Systems, June 2005.

33. P. Frey, R., Jaakkola, T., Moran J. Sequentially Fitting Inclusive Trees for Inference in Noisy-OR Networks. Advances of Neural Information Processing Systems, 13, November 2000.

34. A. Fu, E. Modiano, J.N. Tsitsiklis. Optimal Energy Allocation for Delay-Constrained Data Transmission over a Time-Varying Channel. Proceedings of the 2003 INFOCOM, 2003.

35. A. Giridhar, P. R. Kumar. Computing and Communicating Statistics in Sensor Networks. Proceedings of 2004 IEEE International Symposium on Information Theory, Chicago, June 2004. pp. 80.

36. A. Giridhar, P. R. Kumar. Scheduling Algorithms for Automated Traffic. Proceedings of the 43rd IEEE Conference on Decision and Control, Bahamas , December 2004. pp. 2754-2759.

37. A. Giridhar, P. R. Kumar. Sensor networks: Towards a theory of computation and communication of functions of measurements to a fusion center. Proceedings of 2004 International Zurich Seminar on Communications, Zurich (invited paper), February 2004. pp. 176-178.

38. S. Graham, P. R. Kumar. The Convergence of Control, Communication, and Computation. Proceedings of PWC 2003: Personal Wireless Communication; Lecture Notes in Computer Science, Volume 2775/2003, Springer-Verlag, Heidelberg, 2003, (invited paper), September 2003. pp. 458-475.

39. Guo, S. Shamai, and S. Verdu. Mutual Information and Conditional Mean Estimation in Poisson Channels. 2004 IEEE Workshop on Information Theory, October 2004.

40. Guo, S. Shamai, S. Verdu. Mutual Information and MMSE in Gaussian Channels. Proceedings of 2004 IEEE International Symposium on Information Theory, Chicago, July 2004.

41. Piyush Gupta, P. R. Kumar. A system and traffic dependent adaptive routing algorithm for ad hoc networks. Proceedings of the 36th IEEE Conference on Decision and Control, December 1997. pp. 2375-2380.

42. P. Gupta, R. Gray, P. R. Kumar. An Experimental Scaling Law for Ad Hoc Networks. ACM Intenational Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc 2001), October 2001.

43. Piyush Gupta, P. R. Kumar. Towards an Information Theory of Large Networks: An Achievable Rate Region. Proceeding of the 2001 IEEE International Symposiumon Information Theory, Washington DC, June 2001.

44. M. Gursoy, H. V. Poor, S. Verdu. Power Efficiency of Joint Frequency-Phase Modulation in the Low-SNR Regime over Noncoherent Rician Channels. VTC F04 Transmission Technology, September 2004.

45. M. Gursoy, H. V. Poor, S. Verdu. Spectral Efficiency of Peak Power Limited Rician Block-Fading Channels. Proceedings of 2004 IEEE International Symposium on Information Theory, Chicago, July 2004.

46. M. Gursoy, H. V. Poor and S. Verdu. The Capacity and Power Efficiency of OOFSK Signaling over Wideband Fading Channels. 2004 IEEE Globecom, December 2004.

47. A. Ihler, J. W. Fisher III, A. S. Willsky. Message Errors in Belief Propagation. Advances in Neural Information Processing Systems, December 2004.

48. A. Ihler, J. W. Fisher III, A. S. Willsky. Particle filtering under communications constraints. IEEE Workshop on Statistical Signal Processing, July 2005.

49. Alexander Ihler. Maximally Informative Subspaces: a Nonparametric Approach. MS Thesis, September 2000.

50. A. Ihler, J. Fisher, A. S. Willsky. Nonparametric Estimators for Online Signature Authentication. ICASSP 2001, May 2001.

51. A. Ihler, E. B. Sudderth, W. T. Freeman, A. S. Willsky. Efficient Multiscale Sampling from Products of Gaussian Mixtures. NIPS, December 2003.

52. A. Ihler, J. W. Fisher, A. S. Willsky. Hypothesis testing over factorizations for data association. IPSN, April 2003.

53. A. Ihler, J. W. Fisher III, R. L. Moses, A. S. Willsky. Nonparametric Belief Propagation for Self-Calibration in Sensor Networks. IPSN, April 2004.

54. A. Ihler, J. W. Fisher III, R. L. Moses, A. S. Willsky. Nonparametric Belief Propagation for Sensor Self-Calibration. ICASSP, May 2004.

55. T. Jaakkola, H. Siegelmann. Active information retrieval. Advances in Neural Information Processing Systems, January 2002.

56. J.K. Johnson, E. Sudderth, D. Tucker, M. Wainwright, A.S. Willsky. Multiresolution and Graphical Models for Images and Spatial Data. MiniSymposium on Bayesian Hierarchical Statistical Models for Analysis of Images, SIAM Conference on Imaging Science, March 2002.

57. J.K. Johnson. Estimation of GMRFs by Recursive Cavity Modeling. Masters Thesis, MIT, March 2003.

58. J.K. Johnson, D.M. Malioutov, A.S. Willsky. Walk-Sum Interpretation and Analysis of Gaussian Belief Propagation. NIPS, June 2005.

59. A. Jovicic, S.R. Kulkarni, P. Viswanath. Upper Bounds to Transport Capacity in Wireless Networks. 42nd IEEE Conference on Decision and Control, December 2003.

60. V. Kawadia, S. Narayanaswamy, R. Rozovsky, R. S. Sreenivas P. R. Kumar. Protocols for Media Access Control and Power Control in Wireless Networks. Proceedings of the 40th IEEE Conference on Decision and Control, December 2001. pp. 1935-1940.

61. Vikas Kawadia, P. R. Kumar. Power Control and Clustering in Ad Hoc Networks. Proceedings of INFOCOM 2003, San Francisco, March 2003.

62. V. Kawadia, P. R. Kumar. Experimental Investigations into TCP Performance over Wireless Multihop Networks. ACM Workshop on Experimental Approaches to Wireless Network Design and Analysis (E-WIND 2005), August 2005.

63. O. P. Kreidl, M. Cetin, A. S. Willsky. Collaborative Distributed Inference with Minimal Online Communication. The Learning Workshop at Snowbird , April 2005.

64. S.R. Kulkarni, P. Viswanath. A Deterministic View of Throughput Scaling in Wireless Networks. Proc. International Symposium on Information Theory, July 2002.

65. S.R. Kulkarni, P. Viswanath. Throughput Scaling in Heterogeneous Networks. Proceedings of the 2003 IEEE International Symposium on Information Theory, Yokohama, July 2003.

66. P. R. Kumar. Issues in Ad Hoc Networks: Scaling laws, Media Access Control and Power Control (Keynote Talk). Proceedings of ITCom 2001: The convergence of Information Technologies and Communication, Denver, August 2001. pp. 14-21.

67. P. R. Kumar. The Distributed Nonlinear Stocastic World of Networks. Proceedings of the IUTAM Symposium; Control of Stochastic Systems, Kluwer Academic Publishers, Dordrecht, The Netherlands, Montecello, IL, August 2002. pp. 205-216.

68. P. R. Kumar. Wireless Networks: Analysis, Protocols, Architecture, and Towards Convergence. Proceedings of WiOpt 2003: Modeling and Optimization in Mobile and Ad Hoc and Wireless Networks, Sophia Antipolis, France (Plenary Talk), March 2003. pp. 19-24.

69. P.R. Kumar. Capacity, Architecture, Protocols, and Sensing in Wireless Networks. Proceedings of the 2004 IEEE Information Theory Workshop, October 2004. pp. 469-472.

70. L. Li, A. Tulino, S. Verdu. Design of MMSE Multiuser Detectors using Random Matrix Techniques. IEEE Int. Conference on Communications, May 2003.

71. A. Lozano, A. Tulino, S. Verdu. Correlation number: a new design criterion in multi-antenna communication. Vehicular Technology Conference, April 2003.

72. A. Lozano, A. Tulino, S. Verdu. Multiantenna Capacity in Interference Limited Low-Power Conditions. IEEE Int. Symp. Information Theory, July 2003.

73. A. Lozano, A. Tulino, S. Verdu. High-SNR Power Offset in Multi-Antenna Communication. Proceedings of 2004 IEEE International Symposium on Information Theory, Chicago, July 2004.

74. A. Lozano, A. Tulino, S. Verdu. Power Allocation in Multi-Antenna Communication with Statistical Channel Information at the Transmitter. 15TH IEEE Int. Symp. on Personal, Indoor and Mobile Radio Communications, Barcelona, September 2004.

75. A. Lozano, S.R. Kulkarni, P. Viswanath. Throughput Scaling in Wireless Networks with Restricted Mobility. Proceedings of 2004 IEEE International Symposium on Information Theory, Chicago, July 2004.

76. A. Lozano, A. Tulino and S. Verdu. High-SNR Power Offset in Multi-Antenna Ricean Channel. 2005 IEEE Int. Conf. Communications, May 2005.

77. A. Lozano, A. Tulino and S. Verdú. Mercury/Waterfilling for Fixed Wireless OFDM Systems. IEEE Radio and Wireless Symposium (RWS) (invited paper), San Diego, CA, Jan. 17-19, 2006.

78. D.M. Malioutov, M. Cetin, J. W. Fisher III, Alan S. Willsky. Super-resolution source localization through data-adaptive regularization. IEEE Sensor Array and Multichannel Signal Processing Workshop, August 2002.

79. D.M. Malioutov, M. Cetin, J. W. Fisher III, Alan S. Willsky. Super-resolution source localization through data-adaptive regularization. Adaptive Sensor Array Processing Workshop, March 2002.

80. D.M. Malioutov, M. Cetin, A. S. Willsky. Source Localization by Enforcing Sparsity through a Laplacian Prior: an SVD-based Approach. IEEE Statistical Signal Processing Workshop, October 2003.

81. D.M. Malioutov. A Variational Approach to Array Processing in the Presence of Uncertainties. MIT Masters Thesis, May 2003.

82. D.M. Malioutov, M. Cetin, A. S. Willsky. Optimal Sparse Representations in general overcomplete Bases. ICASSP, 2004.

83. D.M. Malioutov, M. Cetin, A. S. Willsky. Homotopy Continuation for sparse signal representation. ICASSP 2005, 2005.

84. S. Mannor, J. N. Tsitsiklis. Lower Bounds on the Sample Complexity of Exploration in the Multi-Armed Bandit Problem. COLT 2003, LNAI 2777, B. Scholkopf and M.K. Warmuth (Eds.), Springer, August 2003. pp. 418-443.

85. S. Mannor, R. Rubinstein, Y. Gat. The Cross Entropy method for Fast Policy Search. Twentieth International Conference on Machine Learning, August 2003. pp. 512-519.

86. M. Meila, Jaakkola, T. Tractable Bayesian Learning of Tree Belief Networks. Sixteenth Annual Conference on Uncertainty in Artificial Intelligence, December 2000.

87. S.K. Mitter. Control with Limited Information: the Role of Systems Theory and Information Theory. IEEE Information Theory Society Newsletter, vol. 50, December 2000. pp. 1-23.

88. C. Monteleoni, T. Jaakkola. On-line learning of non-stationary sequences. NIPS 03, June 2003.

89. S. Narayanaswamy, Vikas Kawadia, R. S. Sreenivas, P. R. Kumar. Power Control in Ad-Hoc Networks: An Architectural Solution for a Melee of Multiple Agents, Cost Criteria, and Information Patterns. Symposium on Complex Systems Modeling and Optimization in the Information Age to Celebrate 45 Years of Outstanding Contribution of Prof. Yu-Chi "Larry" Ho, June 2001.

90. S. Narayanaswamy, Vikas Kawadia, R. S. Sreenivas, P. R. Kumar. Power Control in Ad-Hoc Networks: Theory, Architecture, Algorithm and Implementation of the COMPOW protocol. Proceedings of European Wireless Conference – Next Generation Wireless Networks: Technologies, Protocols, Services and Applications, Florence, February 2002. pp. 156-162.

91. Ordentlich, G. Seroussi, S. Verdu, K. Viswanathan, M. Weinberger, T. Weissman. Channel decoding of systematically encoded unknown redundant sources. Proceedings of 2004 IEEE International Symposium on Information Theory, Chicago, July 2004.

92. D.P. Palomar and S. Verdú. Estimation-Theoretic Representation of Mutual Information. Forty-third Annual Allerton Conference on Communication, Control, and Computing, Monticello, IL, Sep. 28-30, 2005.

93. D.P. Palomar and S. Verdú. Lautum Information. IEEE Information Theory Workshop, (invited paper) Punta del Este, Uruguay, Mar. 2006

94. Kurt Plarre, P. R. Kumar. Gaussian inference in loopy graphical models. Proceedings of the 42nd IEEE Conference on Decision and Control, Maui, December 2003. pp. 5747-5752.

95. Kurt Plarre, P. R. Kumar, T. I. Seidman. Increasingly Correct Message Passing Algorithms for Heat Source Detection in Sensor Networks. Proceedings of The First IEEE International conference on Sensor and Ad hoc communications and networks (SECON 2004), Santa Clara, October 2004.

96. J. Predd, S.R. Kulkarni, H.V. Poor. Consistency in a Model for Distributed Learning. Proceedings of 2004 IEEE International Symposium on Information Theory, Chicago, July 2004.

97. J. Predd, S.R. Kulkarni, H.V. Poor. Consistency in Models for Communication Constrained Distributed Learning. Proc. 17th Annual Conference on Learning Theory, COLT 2004, Canada, July 2004.

98. R. J. Radke, P. J. Ramadge, S. R. Kulkarni, T. Echigo, S. Iisaku. Recursive Propagation of Correspondences with Applications to the Creation of Virtual Video. IEEE International Conference on Image Processing, September 2000. pp. 250-253.

99. Vivek Raghunathan, P.R. Kumar. A Wardrop routing protocol for ad hoc wireless networks. Proceedings of the 43rd IEEE Conference on Decision and Control, Bahamas, December 2004. pp. 4661-4666.

100. V. Raghunathan, P. R. Kumar. Issues in Wardrop Routing in Wireless Networks. Proceedings of the First International Wireless Internet Conference (WICON 2005), February 2005.

101. A. Reznik, S. R. Kulkarni, S. Verdu. Capacity and Optimal Resource Allocation in the Degraded Gaussian Relay Channel with Multiple Relays. Proceedings of 40th Allerton Conference on Communications, Control and Computing, October 2002.

102. A. Reznik, S.R. Kulkarni, S. Verdu. Scaling Laws in Random Heterogeneous Networks. Proceedings of 2004 IEEE International Symposium on Information Theory, Chicago, July 2004.

103. A. Reznik, S.R. Kulkarni, S. Verdu. Broadcast-relay channel: Capacity Region Bounds. Proc. 2005 Int. Symp. on Information Theory, 2005.

104. C.L. Robinson, G. Baliga, S. Graham, P. R. Kumar. Design Patterns for Robust and Evolvable Networked Control. Proceedings of the Third Annual Conference on Systems Engineering Research (CSER 2005), March 2005.

105. A. Roumy, S. Guemghar, G. Caire, S. Verdu. Design Methods for Irregular Repeat-Accumulate Codes. IEEE International Symposium on Information theory, July 2003.

106. R. Rozovsky, P. R. Kumar. SEEDEX: A MAC protocol for ad hoc networks. Proceedings of The 2001 ACM Intenational Symposium on Mobile Ad Hoc Networking and Computing, (MobiHoc 2001), October 2001. pp. 67-75.

107. A. Sahai. Anytime Information Theory. Ph.D. Thesis, MIT, January 2001.

108. S. Sandilya, S. R. Kulkarni. Principal Curves With Bounded Turn. Proceedings of the International Symposium on Information Theory, June 2000. pp. 321-0.

109. M. Siracusa, Estimating Dependency and Significance for High-Dimensional Data. International Conference on Acoustics, Speech and Signal Processing, M. Siracusa, K. Tieu, A.T. Ihler, J.W. Fisher, A.S. Willsky, March 2005. pp. 1085-1088.

110. N. Srebro, J. Rennie, and T. Jaakkola. Maximum margin matrix factorization. Advances in Neural Information Processing Systems, 17, 2004.

111. Nathan Srebro, T. Jaakkola. Generalized Low-Rank Approximations. ICML 03, February 2003.

112. Nathan Srebro, T. Jaakkola. Linear dependent dimensionality reduction. Advances in Neural Information Processing Systems, 16, 2003.

113. Nathan Srebro, T. Jaakkola. Towards Dependent Dimensionality Reduction: Linear Dependence and Additive Noise. NIPS 03, June 2003.

114. N. Srebro, N. Alon, and T. Jaakkola. Generalization Error Bounds for Collaborative Prediction with Low-Rank Matrices. Advances in Neural Information Processing Systems, 17, 2004.

115. Erik Sudderth, A. T. Ihler, W. T. Freeman, A. S. Willsky. Nonparametric Belief Propagation. MIT LIDS Technical Report 2551, October 2002.

116. Erik Sudderth. Embedded Trees: Estimation of Gaussian Processes on Graphs with Cycles. MIT Masters Thesis, February 2002. pp. 1-164.

117. Erik Sudderth, M. J. Wainwright, A. S. Willsky. Embedded Trees: Estimation of Gaussian Processes on Graphs with Cycles. MIT LIDS Technical Report P-2562, April 2003.

118. Erik Sudderth, A. T. Ihler, W. T. Freeman, A. S. Willsky. Nonparametric Belief Propagation. IEEE Conference on Computer Vision and Pattern Recognition, June 2003.

119. E. Sudderth, M. I. Mandel, W. T. Freeman, A. S. Willsky. Distributed Occlusion Reasoning for Tracking with Nonparametric Belief Propagation. Advances in Neural Information Processing Systems, December 2004.

120. E. Sudderth, M. I. Mandel, W. T. Freeman, A. S. Willsky. Visual Hand Tracking Using Nonparametric Belief Propagation. IEEE CVPR Workshop on Generative Model Based Vision, June 2004.

121. M. Szummer, T. Jaakkola. Partially labeled classification with Markov random walks. Advances in Neural Information Processing Systems, 14, January 2002.

122. Dewey S. Tucker. Multiresolution Modeling from Data and Partial Specifications. MIT Ph.D. Thesis, December 2004.

123. A. Tulino, A. Lozano, S. Verdu. MIMO Capacity with Channel State Information at the Transmitter. 2004 IEEE International Symposium on Spread Spectrum Techniques and Applications, Sydney, September 2004.

124. A. Tulino, S. Verdu. The Shannon Transform in Random Matrix Theory. Bernoulli Society/IMS Congress, July 2004.

125. A. Tulino, S. Verdu. Asymptotic Outage Capacity of Multiantenna Channels. 2005 IEEE Int. Conf. Acoustics, Speech and Signal Processing, March 2005.

126. S.R. Venkatesh, S.K. Mitter. Statistical Estimation and Modeling with Finite Data. ISIT Conference, Lausanne, Switzerland, July 2002.

127. S. Verdu. Error correcting codes and data compression. DIMACS Workshop on Algebraic Coding Theory and Information Theory Workshop, Rutgers University , December 2003.

128. S. Verdu. Connections between Estimation Theory and Information Theory. Information Systems Seminar, Dept. Electrical Engineering, Stanford University, May 2004.

129. S. Verdu. Connections between MMSE Estimation and Information Theory. Proceedings of 2004 International Zurich Seminar on Communications, Zurich (invited keynote address), February 2004.

130. S. Verdu. Estimation Theory and Information Theory: New Connections. 2nd International Workshop on Signal Processing for Wireless Communications, London (invited plenary talk), June 2004.

131. S. Verdu. Physical Channel Research: The Road Ahead. 15TH IEEE Int. Symp. on Personal, Indoor and Mobile Radio Communications, Barcelona (invited keynote speech), September 2004.

132. S. Verdu. The Interplay between Mutual Information and MMSE. IEEE Communication Theory Workshop, Capri, May 2004.

133. S. Verdu. The Interplay between Mutual Information and MMSE. Dipartimento de Elettronica, Politecnico di Torino, Torino, Italy, May 2004.

134. K. Visweswariah, S. R. Kulkarni, S. Verdu. Output Distribution of the Burrows Wheeler Transform. Proc. Intĺ Symposium on Information Theory, June 2000. pp. 53-53.

135. M. J. Wainwright, E. P. Simoncelli, A. S. Willsky. Random cascades of Gaussian scale mixtures and their use in modeling natural images with application to denoising. IEEE 7th International Conference on Image Processing, September 2000.

136. M. J. Wainwright, E. P. Simoncelli, A. S. Willsky. Random cascades on wavelet trees and their use in analyzing and modeling natural images. 45th Annual Meeting of the SPIE, July 2000.

137. M. J. Wainwright, E. Sudderth, A. S. Willsky. Tree-based modeling and estimation of Gaussian processes on graphs with cycles. Advances in Neural Information Processing Systems, November 2000.

138. M. Wainwright, T.S. Jaakkola, A.S. Willsky. A new class of upper bounds on the log-partition function. Snowbird Workshop on Learning, Snowbird, UT, April 2002.

139. M. Wainwright, T.S. Jaakkola, A.S. Willsky. A new class of upper bounds on the log-partition function. Uncertainty in Artificial Intelligence, 2002.

140. Martin Wainwright, T.S. Jaakkola, A.S. Willsky. MAP estimation via agreement on (hyper)trees: Message-passing and linear programming approaches. Allerton Conference on Communication, Control and Computing, October 2002.

141. Martin Wainwright, T. Jaakkola, A. Willsky. Tree-based reparameterization for approximate estimation of stochastic processes on graphs with cycles. Int'l. Symposium on Information Theory, Lausanne, Switzerland, July 2002.

142. Martin Wainwright, T. Jaakkola, A. Willsky. Tree-based reparameterization for approximate inference on loopy graphs. Advances in Neural Information Processing Systems, 2002.

143. Martin Wainwright. Stochastic processes on graphs with cycles: Geometric and variational approaches. MIT PhD thesis, Laboratory for Information and Decision Systems, January 2002.

144. Martin Wainwright, T. Jaakkola, A. Willsky. Tree-reweighted belief propagation algorithms and approximate ML estimation by pseudo-moment matching. Workshop on Artificial Intelligence and Statistics, January 2003.

145. C.-C. Wang, S.R. Kulkarni, H.V. Poor. Bandit Problems With Side Information. 41st IEEE Conference on Decision and Control, December 2002.

146. C.-C. Wang, S.R. Kulkarni, H.V. Poor. Arbitrary Side Observations in Bandit Problems. 42nd IEEE Conference on Decision and Control, December 2003.

147. C.-C. Wang, S.R. Kulkarni, H.V. Poor. Density Evolution for Asymmetric Memoryless Channels. 3rd International Symposium on Turbo Codes and Related Topics, Brest, France, September 2003.

148. C. Wang, S.R. Kulkarni, H.V. Poor. On Finite-Dimensional Bounds for LDPC-like Codes with Iterative Decoding. IEEE Int. Symp. Inform. Theory & Its Appl., October 2004.

149. C. Wang, S.R. Kulkarni, H.V. Poor. On the typicality of the linear code among the LDPC coset code ensemble. 39th Conf. Inform. Sciences and Systems, March 2005.

150. Q. Wang, S. Kulkarni and S. Verdu. Universal Estimation of Divergence for Continuous Distributions via Data-Dependent Partitions. IEEE International Symposium, September 2005.

151. T. Weissman, E. Ordentlich, G. Seroussi , S. Verdu, M. Weinberger. Universal Discrete Denoising: Known Channel. IEEE Int. Symp. Information Theory, July 2003.

152. J. Williams, J.W. Fisher III, A.S. Willsky. An Approximate Dynamic Programming Approach for Communication Constrained Inference. IEEE Workshop on Statistical Signal Processing, July 2005.

153. J. Williams, J.W. Fisher III, A.S. Willsky. An Approximate Dynamic Programming Approach to a Communication Constrained Sensor Management Problem. Eighth International Conference of Information Fusion, July 2005.

154. J. Williams, J.W. Fisher III, A.S. Willsky. Optimization Approaches to Dynamic Routing of Measurements and Models in a Sensor Network Object Tracking Problem. International Conference on Acoustics, Speech and Signal Processing, March 2005. pp. 1061-1064.

155. L.-L. Xie, P. R. Kumar. New Results in Network Information Theory: Scaling Laws and Optimal Operational Modes for Wireless Networks. Proceedings of 41st IEEE Conference on Decision and Control, Las Vegas, December 2002. pp. 3205-3208.

156. L.-L. Xie, P. R. Kumar. New Results in Network Information Theory: Scaling Laws for Wireless Communication and Optimal Strategies for Information Transport. Proceedings of 2002 IEEE Information Theory Workshop, Bangalore, October 2002. pp. 24.

157. L.-L. Xie, P. R. Kumar. Network Information Theory for Wireless Communications. Proceedings of the 2003 IEEE International Symposium on Information Theory, Yokohama, July 2003. p. 288.

158. L.-L. Xie, P. R. Kumar. An achievable rate for the multiple-level relay channel. Proceedings of 2004 IEEE International Symposium on Information Theory, Chicago, June 2004. pp. 3.

159. L.-L. Xie, P. R. Kumar. Wireless Network Information Theory. in Advances in Network Information Theory, DIMACS Series in Discrete Mathematics and Computer Science, Proceedings of the DIMACS Workshop on Network Information Theory, P. Gupta, G. Kramer, A.J. van Wijngaarden (Eds.),

160. American Mathematical Society, Rhode Island, USA., vol. 66, March 2004. pp. 151-158.

161. Xue, L-L. Xie, P. R. Kumar. The Transport Capacity of Wireless Networks over Fading Channels. Proceedings of 2004 IEEE International Symposium on Information Theory, Chicago, June 2004. pp. 370.

162. J. Yu, S. Verdu. Schemes for Bi-Directional Modeling of Discrete Stationary Sources. 2005 Conference on Information Sciences and Systems, March 2005.

(C) Papers presented at meetings but not published

None

(D) Manuscript submitted but not yet published

1. G. Baliga, P. R. Kumar. Middleware for Control over Networks. submitted to Proceedings of the 44th IEEE Conference on Decision and Control (Invited paper), March 2005.

2. L. Bazzi, S.K. Mitter. Some constructions of codes from group actions. submitted to IEEE Trans. on Information Theory, also MIT LIDS Publication 2531, March 2003.

3. A. Corduneanu, T. Jaakkola. Information and transductive estimation. submitted, 2005.

4. Anant Ganti, E. Modiano, J. N. Tsitsiklis. Optimal Transmission Scheduling in Symmetric Communication Models with Intermittent Connectivity. submitted to IEEE Transactions on Information Theory, July 2004.

5. A. Giridhar and P. R. Kumar, "Scheduling Traffic on a Network of Roads," To appear in *IEEE Transactions on Vehicular Technology*, May 2006.

6. Ramesh Johari, S. Mannor, J. N. Tsitsiklis. A Contract-Based Model for Directed Network Formation. to appear in Games and Economic Behavior, submitted November 2003.

7. O. P. Kreidl, M. Cetin, A. S. Willsky. A Message-Passing Algorithm for Optimizing Decentralized Detection Networks. submitted to 44th IEEE Conference on Decision and Control, 2005.

8. D. M. Malioutov, M. Cetin, A. S. Willsky. A Sparse Signal Reconstruction Perspective for Source Localization with Sensor Arrays. IEEE Transactions on Signal Processing (in review).

9. K. Plarre, P. R. Kumar. Object Tracking by Scattered Directional Sensors. Proceedings of the 44th IEEE Conference on Decision and Control (Invited paper), December 2005.

10. R. Radke, P. Ramadge, S. Kulkarni, T. Echigo. Efficiently Synthesizing Virtual Video. submitted to IEEE Transactions on Circuits and Systems for Video Technology, January 2002.

11. V. Raghunathan, P. R. Kumar. A counterexample in congestion control of wireless networks. Proc. of the 8-th ACM/IEEE International Symposium on Modeling, Analysis and Simulation of Wireless and Mobile Systems (MSWIM 2005), October 2005.

12. Alex Reznik, S. Verdu. On the Transport Capacity of a Broadcast Gaussian Channel. submitted to Communications in Information and Systems, 2002.

13. A. Sahai and S.K. Mitter. The Necessity and Sufficiency of Anytime Capacity for Stabilization of a Linear System Over a Noisy Communication Link, Part I: Scalar Systems. submitted to IEEE Trans. on Info. Theory, May 2005.
14. A. Sahai and S.K. Mitter. The Necessity and Sufficiency of Anytime Capacity for Stabilization of a Linear System Over a Noisy Communication Link, Part II: Vector System, submitted to IEEE Trans. on Info. Theory, May 2005.
15. S. Tatikonda, S. K. Mitter. The Capacity of Channels with Feedback, Part I: the General Case. submitted to IEEE Trans. on Info. Theory, October 2001.
16. M. Wainwright, T. Jaakkola, A. Willsky. Tree-based reparameterization for approximate estimation of stochastic processes on graphs with cycles. submitted to IEEE Trans. on Info. Theory, September 2001.
17. M. Wainwright, T.S. Jaakkola, A.S. Willsky. A new class of upper bounds on the log-partition function. submitted to IEEE Trans. on Info. Theory, 2002.
18. M. Wainwright, T.S. Jaakkola, A.S. Willsky. Tree consistency and bounds on the max-product algorithm. submitted to IEEE Trans. on Info. Theory, 2002.
19. M. Wainwright, T.S. Jaakkola, A.S. Willsky. Tree reweighted max-product algorithm and its properties. submitted to IEEE Trans. on Info. Theory, 2002.

(E) Technical reports submitted to ARO

1. Interim Report for 2000
2. Interim Report for 2001
3. Second Year Report
4. Interim Report for 2002
5. Interim Report for 2003
6. Interim Report for 2004
7. Interim Report for 2005